VOL. X APRIL, 1926 No. 2

Entered as second-class matter January 12, 1924, at the post office at Rio Piedras, Porto Rico, under the Act of June 6, 1900.
Acceptance for mailing at a special rate of postage provided for in section 1103, October 3, 1917, authorized January 12, 1924.

THE JOURNAL

OF THE

DEPARTMENT OF AGRICULTURE

OF

PORTO RICO

PUBLISHED BY
THE INSULAR EXPERIMENT STATION
RIO PIEDRAS, P. R.

San Juan, P. R., Bureau of Supplies, Printing, and Transportation, 1926

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EPIPHYTIC ORCHIDS A SERIOUS PEST ON CITRUS TREES

MELVILLE T. COOK

Epiphytic orchids have been frequently reported as growing on citrus trees but the writer does not know of any record of their occurring in sufficient abundance to be destructive. In July 1925, the attention of the writer was called to a citrus plantation between the Carolina Road and Trujillo Alto in which orchids have appeared in such great abundance as to be very destructive. Since that time other cases have been reported.

Two different species of orchid (*Ionopsis utricularioides* (Sw.) Lindl. and *Leochilus labiatus* Kuntze.) were found to be active agents in killing the branches of the trees, but *I. utricularioides* was by far of the greatest importance. Therefore, the greater part of this paper will be devoted to his species. The largest of these plants (Fig. 1) did not have more than six leaves, the largest leaf was nine inches in length and the longest flower shoot was about two feet in length. However, the plants begin blooming when very small. Many plants with leaves a little more than one inch in length produced flower shoots about four inches in length and a few flowers. The roots varied from a few in number to thick masses. A young plant (Fig. 2) is usually supported by three or four roots which grow in any direction for a distance of three or four feet or even more but adhere closely to the host plant. These roots branch rather sparingly, but as the plant increases in size and age new roots are produced which mingle with roots of other plants until the branch is almost completely encrusted for a considerable distance (Fig. 3). As the plants increase in age aerial roots (Figs. 4 and 5) are produced in very great abundance. These aerial roots frequently become attached to neighboring branches and are produced in such great abundance as to give the appearance of a mass of Florida Moss. The aerial roots are not different from those attached to the branches. They are aerial simply because they have not come in contact with any resistant object. If one of these roots comes in contact with a stem or leaf within a reasonable time, they immediately become attached. They frequently become attached to the leaves of the orchid from which they were developed.

The infections vary from a single small plant to dense masses of plants of various ages and sizes. The writer counted as many as twenty plants within a distance of twelve inches. The plants were also found clustered in masses (Fig. 5). A careful examination indicated that these plants came from seeds. When carefully dissected out, it was evident that each plant had its own root system. This had to be determined almost entirely from the study of very small plants because plants of one inch in length usually produced such lengthy root systems that it was difficult to follow them. The encrustation of roots on the surface of a branch afforded a most excellent place for the lodgement of seeds and thus gave rise to the great number of plants of various ages and sizes within a small area. The writer failed to find a single case in which two plants had a united root system. The roots when dry are very grey but many of them develop a light green color when young and in the presence of moisture.

The infections are most abundant in reduced sunlight and moisture but none were found in dense shade and excessive moisture. The infections usually start by the development of one or more seedlings on a branch or twig where it is well shaded. When the plant is ready to produce fruit, the flowering shoots grow upwards and into the sunlight. Small plants, producing short flowering shoots previously referred to are usually exposed to the sun as a result of the dying of the leaves of the host. The larger plants produce longer flowering shoots and more flowers, the flowering shoots always carrying the flowers into the sunlight. Although the plants start and develop in the shade and are seldom exposed to the direct sun light, except as a result of the dying of the leaves of the host, the flowers are always borne in the direct sunlight. It, therefore, appears that the strong sunlight may stimulate flowering. The plants fruit very freely and produce enormous numbers of very small seeds. These seeds are so small and light that they are easily carried by the wind to the same or neighboring trees, where some few of them germinate and give rise to new plants. Naturally the greater the distance from the point of origin the more scattered the new infections. It was very easy to locate these original infections and to trace the new infections from these centers.

The effects of the Orchids on the host plant was that of strangulation (Figs. 2–6). The roots grow very rapidly and increase with the number and age of the plants and practically cover the entire surface of the branch for a considerable distance. The infected

branches were eventually killed. Sometimes branches as much as three inches in diameter were killed. The killing of these branches very naturally destroyed the symmetry of the trees, gradually weakened them, reduced production and eventually killed them. The rapid spread of this pest was a surprise to the writer, who visited this plantation thirteen months previous to the discovery of this outbreak.

L. labiatus (Figs. 7 and 8) is a very much smaller plant, was much less abundant and much less destructive. There was no evidence that any branches more than three-fourths of an inch in diameter had been killed by this species. It appeared that this species was more tolerant to sunlight than *I. utricularioides.*

CONTROL

The control of these pests is comparatively simple. It consists in the removal of the plants so far as possible and in some cases the removal of heavily infected branches. Since the plants always start from seeds and not from the branching root systems, it is not necessary to remove all the roots. It is advisable to take the above precautions previous to spraying the trees, since the spraying fluids may kill some of the seeds and some of the very small plants which have been overlooked.

EXPLANATION OF PLATES

Figure 1: *Ionopsis utricularioides*, showing flowers, seeds pods and roots attached to the plant from which they were developed.
Figure 2: Young plants on a grapefruit branch.
Figure 3: Numerous small plants with well-advanced root systems on a grapefruit branch.
Figure 4: A number of plants on a dead branch. Also shows aerial roots.
Figure 5: Same as 4.
Figure 6: A number of young plants on a branch which is still alive.
Figures 7 and 8: *L. labiatus.*

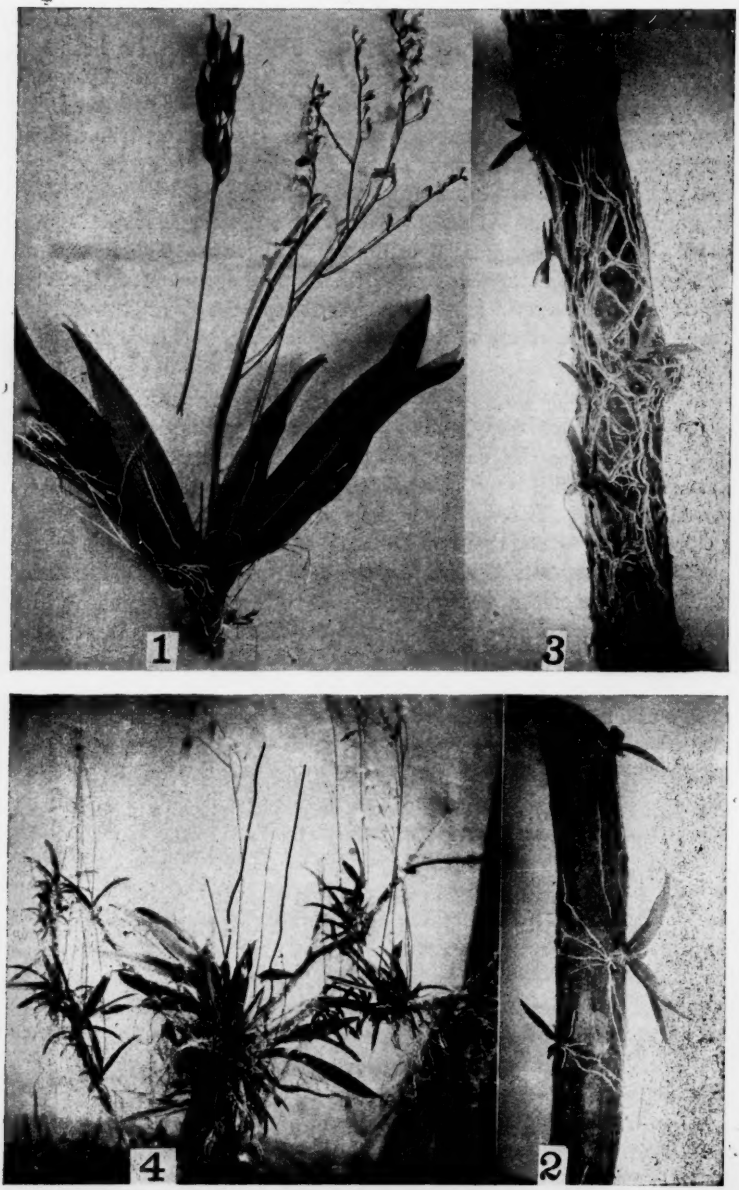

FIGURE 1.—*Ionophis utricularioides*, showing flowers, seed pods and roots attached to the seed plants from which they were developed.
FIGURE 2.—Young plants on a grapefruit branch.
FIGURE 3.—Numerous small plants with well-advanced root systems on a grapefruit branch.
FIGURE 4.—A number of plants on a dead branch. Also shows aerial roots.

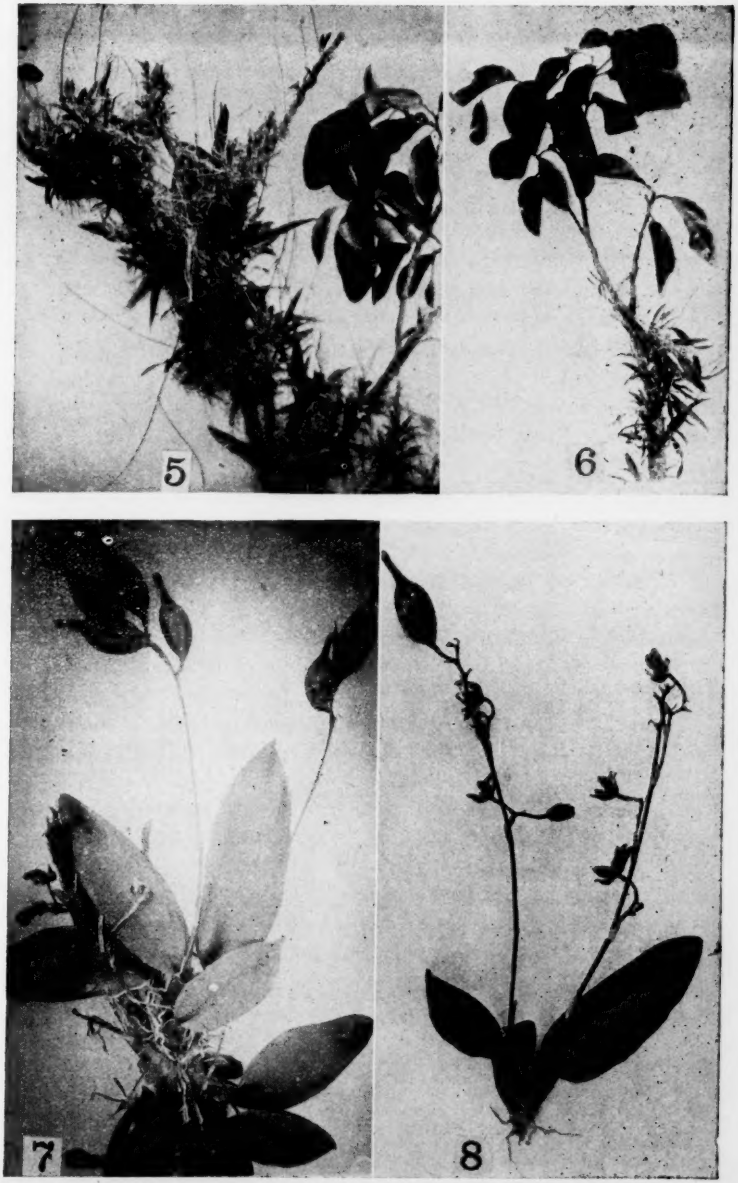

FIGURE 5.—Same as 4.
FIGURE 6.—A number of young plants on a branch which is still alive.
FIGURES 7 AND 8.—*L. labiatus.*

MYCOLOGICAL NOTES I[1]

RAFAEL A. TORO

(With one plate and one figure on the text)

The purpose of these notes is to present the results of the studies of the mycological flora of the Island of Porto Rico. The bulk of the literature already in existence on this subject contains several disagreements regarding the identity of some of the forms studied, and makes necessary a detailed and comprehensive revision of some of the groups.

The study of the tropical flora has been for a long time a subject of interest to those engaged in botanical classification of phanerogams, although, from the start, some cryptograms were incidentally collected and studied. The fungi collected in Porto Rico by P. Sintenis in 1881 were studied by Bresadola, Hennings and Magnus (Eng. Bot. Jahr. **17**[5]: 489–501. 1893.) and recorded by Stevenson (Journ. Dept. Agric. Porto Rico **2**[3]: 125–264. 1918.). Those collected by C. Schwanecke in 1846 were studied by Klotsch (Linnea **25**: 364–366. 1852.) and also recorded by Stevenson. We find in Stevenson's paper a record of only one of the fungi collected by Bertero in 1818. This fungus was described by Léveillé (Ann. Sci. Nat. **3**[2]: 177. 1844.) under the name *Heliomyces berteroi* sp. nov. and was restudied and transferred by Murrill (N. Am. Fl. **9**[4]: 267. 1913.) to *Marasmius berteroi* (Lev.) comb. nov. However, other fungi were also collected by Bertero and described by Montagne (Ann. Sci. Nat. **8**[2]: 345–470. 1837.) and Léviellé (Ann. Sci Nat. **3**[3]: 38: 77. 1845.) but not recorded by Stevenson. Montagne is, apparently, the first scientist to describe a fungus from Porto Rico. By way of introduction to these notes and as a matter of historical interest in mycology a presentation is here given of this description by Montagne:

"36. *Dothidea* (Asteroma) *Eugeniae* (Montag. mass.); amphigena, maculaeformis, centro opaca atra fibrillis ramoso-pinnatis, ramis patentibus in ambitu radiata, cellulis confertis minimis collapsis ostiolo instructis.

"hab. in foliis vivis cojusdam Eugeniae speciei in Porto Rico a Bertero et mecum sub nomine *Depazeae eugeniae* a Balbisio communicata.

[1] The writer wishes to acknowledge his obligations to Dr. F. J. Seaver of the New York Botanical Garden for the facilities rendered during the writer's stay at that Institution and to Dr. Mel. T. Cook for reading and correction of the manuscript.

"Elegans uti sunt pleraeque species hujus tribus. Maculae amphigeneae, variae amplitudinis, confluentes, saepius minimae, 1–2 lineas latae, centro opacae, ambitu fibrillis tenuissimis atriculatis ramoso-pinnatis, ramis alternis decrescentibus radiatae. Cellulae praesertim in centro macularum confertae, sed tamen distinctae, minutissimae, collapsae, pezizaeformis, eumorphae, ostiolo sub vitris augentibus tantum conspicuo instructae et sat similes peritheciis *Sphaeria complanatae* Tode, a quibus mole solum primo intuitu recedunt."

This fungus is also recorded by Saccardo (Syll. Fung. **1**: 49. 1882.) in his section *Asteridium* under the name of *Asterina eugeniae* Mont. It can not be an *Asterina* since Saccardo states in the description that the spores are three-septate. Theissen (Abh K. K. Zoo-Bot. Ges. Wien **7**[3]: 25. 1913.) also excludes the species from *Asterina* Lév. because "Nach der Beschreibung sind die Sporen vierzellig". The writer examined a specimen from South America, deposited in the herbarium of the New York Botanical Garden and labelled *Dothidea Eugeniæ* Mont., and found that there are no asci or spores on the fungus.

Léveille describes two other fungi from Bertero's collection: *Sphaeria ecastophylli* sp. nov. on leaves of *Pterocarpus Ecastophyllum* and *Stilbum berteroi* sp. nov. on dead twigs. The first species was transferred by Saccardo (Syll. Fung. **1**: 446. 1882.) to *Physalospora Ecastophylli* (Lév.). The other species is still known under its original name. In his paper, Lévielle reports for the first time from the Island, *Meliola amphitricha* Fr. on leaves of *Aralia arborea*. This fungus may be the same as *Meliola araliæ* collected in 1884 in Porto Rico on leaves of *Dendropanax arboreum* (L.) Dene. y Pl. and reported by Stevens (Illinois Biol. Monog. **2**: 505. 1916.).

1. Calothyrium Ingae Ryan.

The genus *Calothyrium* was established by Theissen (Ann. Myc. **10**: 160. 1912.) to include those species formerly assigned to *Asterina* Lév. having hyaline spores and mycelium devoid of hyphopodia. For the brown-spored forms the new genus *Asterinella* Th. was also proposed.

According to Arnaud (Les Asterinées **1**: 150. 1918.) the generic characters of *Microthyrium* Desm. were not well delimited. He found that the type-species, *M. microscopicum* Desm., is provided with superficial mycelium and resembles in general characters *Asterinella Puiggarii* (Speg.) Th. For this reason he amended the description of *Microthyrium* Desm., including among its characters the presence of superficial mycelium. The writer examined at the New York Botanical Garden a specimen labelled "*Microthyrium*

microscopicum Desm''. (Rab. & Wint. F. Europ. No. *2943*) and found that it has a very scanty superficial mycelium. Undoubtedly the genera *Calothyrium* Th. and *Microthyrium* Desm. are the same, while *Asterinella* Th. differs from either only in having colored spores. The genus *Calothyrium* Th. then becomes a synonym of *Microthyrium* (Desm.) Arnaud. Therefore, *Calothyrium ingae* Ryan becomes **Microthyrium Ingae** (Ryan) comb. nov.

On leaves of *Inga Inga* (L.) Britton. Porto Rico Fungi (Stevens). *No data.*

Spots none; colonies more or less circular, 5–10 mm. in diameter, membranous, black at the center, pale toward the edges; mycelium without hyphopodia, 3u. in diameter, straight, rarely anastomosing, light brown, septate; 90–110u. in diameter, astomous at first, ostiolate at maturity and dehiscing by desintegration of the cell walls, fuliginous, coriaceous, finely denticulate at the borders, prosenquimatous-radial, with thin, scarcely septate straight threads; asci oval-obovate, 14–18 × 14u., 8-pored, thick-walled and roundish at the upper portion sub-cuneiform at the lower and terminating in a thick, short pedicel; spores inordinate, cylindric-fusoid, 10–12 × 2–3u., 1-septate, the superior cell obtuse, sub-globose, the inferior acute, slightly constricted, hyaline; paraphyses filiform, mucilaginous.

C. Hippocrateæ Ryan may, according to the description, also belong to *Microthyrium* Desm. Since no material of this fungus has been available it is temporaly left under the former.

2. **Microthyrium Psychotriae** (Ryan) comb. nov.

The fungus *Calothyrium Psychotriæ* Ryan is also a *Microthyrium*. It forms no spots on the leaves but the subiculum consists of rather irregular, black crusts 2–5 mm. in diameter; the thiriothecia are 110–115u. in diameter, opaque-fimbriate, provided with ostiolo but dehiscing by desintegration of the radiate hyphæ which make up the peritheci l elements; the mycelium is brown, 4–6u. thick, closely septate and nearly straight; the asci round, sessile, the upper portion very thick-walled, the lower thinner, 12–20u. in diameter, 8-spored; spores inordinate, elliptical, 2-celled, 5–7 × 2–3u., hyaline (Plate I, Figs. 4 & 5.).

On leaves of *Psychotria* sp. Porto Rico Fungi (Stevens) No. *6662.*

3. **Lembosia microspora** Chardón and **Morenoella portoricensis** Speg.

The genus *Lembosia* Lév. differs from *Morenoella* Speg. in having

asci provided with paraphyses. The descriptions of *Lembosia microspora* Chardón (Mycologia **13**: 282. 1921.) and of *Moronoella portoricensis* Speg. (Bol. Acad. Nac. Ci. Córdoba **26**: 343. 1923), however, state that paraphyses are present in both species. The writer has examined several specimens of these two fungi and has found that the presence or absence of paraphyses is a very unstable character on which to determine the generic position of these species. According to the stage of maturity of the fungus, one will find sometimes distinct, sometimes few, or sometimes no paraphyses. The same has been found to apply to genera which are differentiated by their variations in structure of the free mycelium, for instance, as to the presence or absence of mycelial setæ or hyphopodia. So differs *Irene* Th. & Syd. from *Meliola* Fr. In *Irene* the mycelial setæ are wanting while they are present in *Meliola*. But from the examination of fresh material in the tropics the writer is convinced that *Irene* species with mycelial structures resembling setæ may also occur as *Meliola* with typical setæ, and vice versa, depending upon weather conditions, character of the host and stage of development of the fungus. Such genera, and many others, therefore, have very low value, but they considerably increase the already existing uncertainty and will frequently cause errors. It would be much better and more in accordance with natural conditions if such genera would only be considered as sub-genera. The writer (Mycologia **17**: 131–147. 1925.) recognized the genus *Irene* Th & Syd. as having well-defined characters, but only forms which do not show traces of typical setæ and have no mycelial structures resembling them, are considered. However, after more extensive studies it may possibly be found that even the complete absence of setæ is not a stable character, in which case it will be necessary to consider the genus as a section of the older genus *Meliola* Fr. The same may be applied to *Appendiculella* v. Höhnel, which differs from *Meliola* Fr. in the presence of vermiform perithecial appendages.

In his description of *Lembosia microspora,* Chardón makes the statement that hyphopodia are absent. However, upon re-examination of his type and other material it has been found that there are very distinct hyphopodia on the mycelium, although sometimes these are wholly absent. It was also noticed that these hyphopodia can be very easily mistaken for the basal cells of broken mycelial hyphæ which remain attached after the rest of the hyphæ have been

separated. They are cylindric, 1-celled, pointed toward the ends and of the same color as the mycelium.

From the studies of the type-materials of *Lembosia microspora* Chardón and of *Morenoella portoricensis* Speg., the writer found that the dimensions of the different elements overlap and that there is no difference between the species. Also since they have the same general characteristic and occur on the same host there is no doubt that we are dealing with the same fungus in both cases. The name given by Chardón must be retained as valid for reason of priority, but the description needs to be emended.

LEMBOSIA MICROSPORA (Chardón) char. emend.

Lembosia microspora Chardón, Mycología **13**: 282. 1921.

Morenoella portoricensis Speg., Bol. Acad. Nac. Ci. Córdoba **26**: 343. 1923.

Echidnodes microspora (Chardón) Seaver & Toro. Sci. Surv. Porto Rico **8**: 41. 1926.

Spots none; colonies amphigenous; mycelium widely spreading, septate, 3–4u. in diameter, light-brown, branched, anastomosing; hyphopodia straight-cylindric or sub-ampulliform, small, 1-celled; thyriothecia scattered, black, often curved, 200–800 × 100–200u.; asci obovate-ellipsoidal, 8-spored, 18–25 × 15–20u.; spores inordinate, 1-septate, constricted at septum, 10–15 × 4–5u., hyaline at first, becoming dark-brown with age; pseudoparaphyses present.

On leaves of *Ocotea leucoxylon* (Sw.) Mez. Cornell University Explorations of Porto Rico (Whetzel & Olive) *621* (Type of Chardón's species); Porto Rican Fungi (Stevens) *7563, 4762, 8459, 9433* (Type of Spegazzini's species according to Ryan, Mycologia **16**: 193. 1924.), *4739, 9436, 9422, 7349,* (Deposited in herbarium New York Botanical Garden).

Colonies thinly diffuse, more or less round, 5–20 mm. in diameter; mycelium thin, 3–4u. in diameter, straight, frequently anastomosing and at right angles to the hyphæ, light-brown, septate; hyphopodia numerous, generally opposite, at right angles to the mycelial hyphæ, cylindric and pointed toward the ends, 8–12 × 3–4u., 1-celled, light-brown; thiriothecia linear, 200–800 × 100–200u. scattered, dehiscing by a longitudinal slit, black, borders fimbriate, of thin, 2–2.5u. thick, light-brown hyphæ; asci obovate-ellipsoidal, 18–25 × 15–20u., thick-walled at the upper portion, thinner at the lower, 8-spored; spores inordinate, cylindric, 10–15 × 4–5u., unequally 1-septate, constricted at septum, hyaline at first, becoming dark-brown with age; pseudo-paraphyses filiform, numerous.

4. Leprieurina radiata sp. nov.

Spots none; fungus amphigenous, forming black, irregular crusts 5–20 mm. in diameter; pycnidia round, radial, 210–225u. in diameter, formed of light-brown cells about 12u. long and 3u. thick; ostiolum small, round, 10–12u. in diameter; mycelium dark-brown cob-webby, non-hyphopodiate, 6–8u. wide; coniodophores inconspicuous, 2–5u. long, hyaline; spores one-celled when young, hyaline, becoming two celled with age and with an olivaceous tint, oblong-elliptic, 9–16 × 3–5u. (Plate I fig. 2–3).

On leaves of *Chrysobalanus icaco* L., Loíza, P. R. Herbarium R. A. Toro *428* (Type).

The microscopical characteristics of this fungus is microthyriaceous and it is undoubtely a pycnidial form of one of the genera of this ascigerous group. The pycnidia are dimidiate and inverse-radiate like the perithecia of the Microthyriaceæ. They are solitary or in groups, posses an ostiolum but dehisce by desintegration of the walls. The mycelium is devoid of hyphopodia, like the mycelium of the ascigerous genus *Asterinella*, and forms a net of cross-webby threads by the anastomosing of the hyphæ. The spores arise from underneath the upper part of the pycnidia and very often, the small inconspicuous conidiophore remains attached (Plate I, fig. 3) so that it gives the spore the appearance of being ciliate. A character which makes this fungus very distinct from any other form thus far described is that the spores are oblong-elliptic instead of pyriform as is the case with the other species.

The systematic position of the genus *Lepricurina* is uncertain It has the same characteristics as *Asterostomella*, a fungus described by Spegazzini (Fungi Guaranitici **1**: 157. 1883.) and originally placed by him among the Leptostromatacea of the Fungi Imperfecti. He indicated that *Asterostomella* is a pycnidial form of *Asterinæ*. There is no family among the Fungi Imperfecti that would accommodate the inverse-radiate, superficial pycnidial forms of the Microthyriacea. The abundance of superficial mycelium and the character of the pycnidium makes the group unlike any other of the Fungi Imperfecti. Arnaud (Les Asterinés **1**: 204. 1918.), realizing this fact, proposes the family Microthyriopsidees for this group including the genus *Asterostomella* as type, and characterizing the genus as having colored-spores. *Leprieurina* Arnaud is also placed on this group, differing from *Asterostomella* in having 2-celled spores.

5. Perisporium Bromeliae Stevens.

Perisporium bromeliæ is described by Stevens (Trans. Illinois Acad. Sci. **10**: 168. 1917.) on leaves of *Bromelia Pinguin* L. This most interesting fungus was placed in this genus with some uncertainty as it shows relationship with different genera of the Perisporiaceæ and Sphaeriaceæ, although sufficiently distinct from either to constitute a new species. Stevens (1. c.) places the species under *Perisporium* Fr. since it agrees most closely with this genus although it differs in having 4-spored asci.

The writer compared the type-species of *Perisporium bromeliæ* Stev. (Stevens, Porto Rico Fungi No. *4329*) with a specimen of *Asteridium dimerosporioides* Speg. (C. Roumerguére Fungi selecti exsiccati No. *5244*) deposited in the herbarium of the New Botanical Garden and found them to be the same. This fungus, described by Spegazzini (Fung. Guar. **II**: 50. 1888.) on leaves of *Caraguata* sp., was transferred by Saccardo (Syll. Fung. **IX**: 434. 1891.) to *Zukalia dimerosporioides* (Speg.). Later, v. Höhnel (Frag. zur Myk. **157**: 617–618. 1917.) discussed fully the affinities and relationships of *Asteridium dimerosporioides* Speg. and placed it on the Hypocreales under the new combination *Gibberella dimerosporioides* (Speg.).

Recently, González Fragoso and Ciferri (Rev. Soc. Española Hist. Nat. **25**: 499. 1925.) described and illustrated *Chaestosphaeria bromeliæ* sp. nov. on leaves of *Bromelia peregrina.* However, several collections of this same fungus, on *Bromelia Pinguin* L., were made in Santo Domingo by Kern and Toro. They were shown to Dr. Ciferri and he said the fungus is the same they had described as *Chaetosphaeria bromeliæ.* This fungus, on the other hand, was compared by the writer with *Perisporium bromeliæ* Stevens and found that they are the same. There is, nevertheless, some inconsistency in the statements regarding the number of spores in the ascus. González Fragoso and Ciferri say the ascus is 8-spored; Stevens says it is 4-spored. This same disagreement exists on the discussions of Spegazzini and v. Höhnel. Sydow and the writer have found that the asci are 4-spored instead of 8-spored. It is not surprising that the asci may appear as being 8-spored, since their walls are evanescent and when one ascus lies over the other and their walls desintegrate it gives the appearance as of being twice the actual number of spores. This same observation is made by v.

Höhnel and he says that "Spegazzini gibt die Asci vier-bis achtsporig an; doch wird dies ein Irrtum sein, da in 50 × 25u. grosen. Asci kaum acht 26–8u. grossen Sporen Platz haben. Ich fand die Asci stets viersporig, doch wenn zwei Asci übereinander liegen, kann man sie leicht für achtsporig halten."

The setæ observed on the perithecium by González Fragoso and Ciferri may be due to an error of vision. The writer has always found that the mycelium consists of rather stiff, setæ-like, septate hyphæ growing more or less horizontally to the subtratum and occurring only at the furrows between the veins of the leaf; but

FIGURE 1.—Photomicrograph of a cross-section of a leaf of *Bromelia Pinguin* L. showing the position of the perithecia of *Toroa dimerosporioides*. (A) Perithecia between the veins of the leaf. Notice the setæ-like mycelial hyphæ faintly shown on the left-hand side of the first perithecium. (B) Cross-section of a perithecium. × 90.

never arising from the perithecium. The perithecium is provided with a papilla and dehisces at maturity by desintegration of the cell-walls. These characters are unlike any other hitherto described for a fungus of this group and are sufficient to justify the establishment of a new genus. Moreover, the type of the genus *Perisporium* Fr., *P. gramineum* Fr., is, according to Saccardo (Syll. Fung. I: 56. 1882.), synonymous with *Crocicreas* Fr., one of the Excipuleae; the type of *Asteridium* Sacc., *A. pleurostylix* Sacc., is a *Meliola* according

to Theisseen and Sydow (Ann. Myc. **15**: 424. 1927.), while *Zukalia* Sacc. is synonymous with *Chætothyrium* Speg. (Theissen and Sydow l. c. 477.). From the standpoint of modern procedure in nomenclature the generic names *Perisporium* Fr., *Asteridium* Sacc. and *Zukalia* Sacc. has no standing whatever and must be abandoned. However, Spegazzini (Bol. Acad. Nac. Ci. Córdoba **26**: 348. 1923.) claims that the name *Asteridium* Sacc. is to be retained since Saccardo when establishing the genus had in mind a dimidiate perithecium and not a cleistocarpus one as is the fruiting body of *Meliola* Fr. He, therefore, emends the characters of this genus, re-establishes the name and places it in the Dyctiopeltineæ of the Hemisphæriales. It is an undeniable fact that such procedure can not be accepted since it is impossible that Spegazzini could have been able to ascertain what Saccardo had in mind when he established the genus *Zukalia*, and moreover, such abstract-concept genera, supposing we accept this as one, are not altogether recommendable as they very often cause confusion. There is no doubt also that the fungus is not a *Gibberella* since its characters do not agree with what we understand as such.

Abundant material of *Perisporium bromeliæ* Stev. was collected in Porto Rico and sent to Dr. H. Sydow. After examination of this and some of Stevens' duplicates he decided that this fungus is a new genus and described it as follows:

Toroa Syd. gen. nov.

Myzel oberflächlich, fleckenförmige oder ausegebreitete schwärzliche Überzüge bildend, teils aus anliegenden meist stark gekrümmten, teils aus etwas abstehenden und ziemlich steifen Hyphen bestehend. Hyphopodien fehlen. Perithecien im Hyphenfilze des Myzels nistend, aussen, besonders unten, von demselben bekleidet, ziemlich klein, kuglig, völlig geschlossen, aber fast immer mit deutlicher flacher Scheitelpapille versehen, bei der Reife zerfallend. Membran brüchig-kohlig, mehrzellschichtig, fast opak schwarzbraun. Asci dickwandig, aber leicht zerfliessend, dick keulig, 4-sporig, sitzend. Sporen breit länglich-spindelförmig, ziemlich gross, mehrzellig, durchscheinend olivenbraun. Paraphysoiden sehr spärlich, undeutlich faserig-zellig. (Mycelium superficial, forming blackish crusts, hyphæ slightly bent or stiff; hyphopodia wanting; perithecia seated on the mycelium, spherical, nearly always provided with a papilla, dehiscing at maturity

by desintegration of the cellwalls; membrane brittle-carbonaceous, composed of many layers of cells, black-brown; asci thick-walled, evanescent, ovate, sessile, 4-spored; spores oblong-spindleform, many-celled, translucent, olive-brown; paraphyses sparse, indistinct, filiform.)

Toroa differs from *Meliola* Fr. chiefly in its papillate perithecia and in the shape, color and septation of the spores.

Type species the following:

Toroa dimerosporioides (Speg.) Syd. comb. nov.

Asteridium dimesrosporioides Speg. Fungi Guaranitici **II**: 17. 1888.

Zukalia dimerosporioides (Speg.) Sacc., Syll. Fung. **IX**: 434. 1891.

Gibberella dimerosporioides (Speg.) v. Höhnel, Sitz K. Akad. Wiss. Wien **116**: 617-618. 1917.

Perisporium Bromeliae (Stev.) Trans. Illinois Acad. Sci. **10**: 168. 1917.

Chaetosphaeria bromeliae Frag. & Cif. Bol. R. Soc. Española Hist. Nat. **25**: 449. 1925.

Myzel oberflächlich, nur hypophyli, bald ziemlich kleine, ganz unregelmässig eckige ca. 1–1.5 cm. grosse, schwärzliche, ziemlich scharf begrenzte Flecken, bald mehr oder weniger weit ausgebreitete, oft grosse Teile des Blattes gleichmässig überziehende, grauschwärzliche, ziemlich lockere wollig filzige Überzüge bildend, aus dünnwandigen der Epidermis anliegenden durchscheinend olivenbraun gefärbten, ziemlich kurzgliedrigen, ca. 3–5u. dicken, meist stark und verschieden gekrümmten Hyphen bestehend, von welchen sich dünnwandige, durchscheinend schwarzbraune, ca. 3–4u. dicke, bis über 600u. lange, mehr entfernt septierte, ziemlich steife, wirr durcheinanderlaufende, fast borstenartige Hyphen erheben, aber bald eine zur Oberfläche des Substrates mehr oder weniger horizontale Richtung einnehmen und ein in den Furchen zwischen der Nerven bis ca. 100u. hohes, ziemlich lockeres Geflecht bilden, in welchen die Perithecien nisten. Perithecien nur in den Furchen zwischen den Nerven in lockeren oder dichten parallelen Längsreihen wachsend, meist ziemlich regelmässig rundlich, ca. 80–130u. im Durchmesser, vollständig geschlossen, aber mit einer flachen, gestutzt kegelförmigen oft ziemlich undeutlichen Papille am Scheitel, bei der Reife meist ganz zerfallend. Peritheciummembran brüchig-kohlig, aus einigen Lagen von fast opak schwarzbraunen, mehr oder weniger zusammengepressten sehr unregelmässig eckigen, ziemlich dünnwandigen, etwa 4–7u., seltener

bis ca. 10u. grossen Zellen bestehend, aussen durch schwach vorspringende Zellen und kleine Zellkomplexe sehr feinkörnig rauh, besonders unten locker mit Hyphen des Myzelfilzes besetzt, innen rasch in eine dünne hyaline oder fast hyaline undeutlich konzentrisch faserige Schicht übergehend. Asci in geringer Zahl, dickkeulig oder länglich ellipsoidisch, am Scheitel etwas vorgezogen, mit stark verdickter Scheitelmembran, stumpf abgerundet, nach unten hin stark erweitert, dann plotzlich zusammengezogen, sitzend oder sehr undeutlich und kurz gestielt, dickwandig, aber leicht zerfliessend, 4-sporig. Sporen ziemlich breit länglich-spindelförmig, beindendig ziemlich stark und gleichmässig verjüngt, stumpf abgerundet, gerade oder schwach sichelförmig gekrümmt, mit 2 ungefähr im oberen und im unteren Viertel der ganzen Länge befindlichen Querwänden versehen, nicht oder nur sehr undeutlich eingeschnürt, mit ziemlich grobkörnigem Plasma oder mit 1–2 undeutlichen aber ziemlich grossen Oltropfen, die mittlere Zelle meist ca: 15–17u. lang tonnenförmig durchscheinend olivenbraun, die beiden Endzellen etwa 7–8u. lang stumpf konisch und meist deutlich heller gefärbt, im ganzen 25–36u. lang. 9–11u. dick, Paraphysoiden sehr spärlich, undeutlich, faserig zellig. (Mycelium superficial, bypophyllous, forming small, irregularly angled, black, definite spots about 1–1.5 cm. in size, sometimes confluent to form larger spots: outer walls of the host epidermis stained brown; hyphæ thin-walled, translucent, black-brown, 3–4 thick, up to 600u. long, septate, somewhat stiff, bristle-like, more or less horizontal to the substratum and then about 100u. high, always on the furrows between the veins of the leaf and with the perithecia seated on them; perithecia in loose or compact longitudinal rows, spherical, 80–130u. in diameter, astomous but with a conical papilla, dehiscing at maturity by desintegration of the cell-walls; membrane black-brown, cells thin-walled, 4–7u. large; asci few, ovate or elongate-ellipsoid, thick-walled at the upper portion, sessile or with a very short pedicel, evanescent, 4-spored; spores oblong-fusiform, straight or slightly curved, irregularly 2-septate, with 1 or 2 indistinct but some what large oil drops; 25–36 × 9–11u., translucent, olive-brown, the middle cell about 15–17u. long, barrel-shaped; end cells about 7–8u. long, obtuse-conic; paraphyses sparse, indistinct, filiform.

On leaves of *Bromelia Pinguin* L. Herbarium University of Illinois (Stevens) No. *4329*. Cornell University. Explorations of Porto Rico (Whetzel, Kern and Toro) No. *2536*. University of Porto Rico Explorations of Santo Domingo (Kern and Toro). No *194*, and *207*.

On *Caraguata* sp. (C. Romerguére Fungi selecti exsiccati No. *5244.*) South America.

6. Asterina Melastomacearum Ryan.

The fungus *Asterina Melastomacearum* sp. nov. is described by Ryan (Mycol. **16**: 186. 1924) on leaves of *Miconia racemosa* (Aubl.) DC. and *M. impetiolaris* (Sw.) D. Don., respectively. Two specimens of this fungus have been examined by the writer (Porto Rico Fungi (Stevens) Nos. *7037, 375*) and both agree with the description given by Arnaud (Les Asterinés **I**: 168. 1918) for *Asterina Melastomatis* Lév. The fact that this fungus is very common in other parts of the world on members of the *Melastomaceæ*, makes more certain the possibility that *Asterina Melastomacearum* Ryan is the same as *Asterina Melastomatis* Lév., in which case the former becomes a synonym of the latter for reason of priority (Plate I, figs. 8, 9 & 10).

EXPLANATION OF PLATE I

FIGURE 2.—Diagramatic sketch of a leaf of *Chrysobalanus Icaco* showing the distribution of colonies of *Leprieurina radiata*. × 1.

FIGURE 3.—Spores of *Leprieurina radiata* sp. nov. Notice the persistent sporophore on one of the spores. × 800.

FIGURE 4.—Ascus and spores of *Microthyrium Psychotriae* (Ryan) comb. nov. × 800.

FIGURE 5.—Diagramatic sketch of a leaf of *Psychotriae* sp. showing colonies of *Microthyrium Psychotriae*. (Leaf × .5, colonies × 2.)

FIGURE 6.—A perithecium of *Toroa dimerosporioides* (Speg.) Syd. showing method of dehiscing. Also the setaelike character of the mycelium is shown. × 95.

FIGURE 7.—Two spores of *Toroa dimerosporioides*. × 800.

FIGURE 8.—Mycelium and hyphopodia of *Asterina Melastomatis* Lev. × 800.

FIGURE 9.—An ascus with spores of *Asterina Melastomatis*. × 800.

FIGURE 10.—Two spores of *Asterina Melastomatis*. × 800.

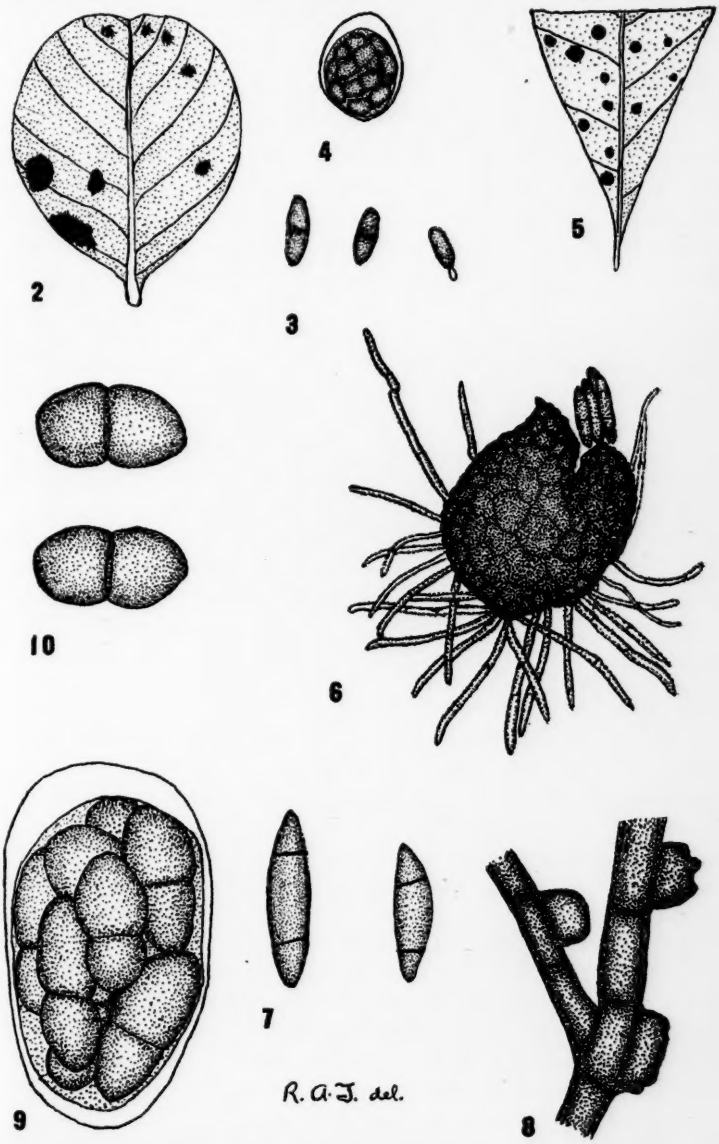

PLATE I

THE ANTHRACNOSES OF CITRUS FRUITS, MANGO AND AVOCADO

J. A. B. Nolla

INTRODUCTION

The present paper presents a comparative study of the anthracnose diseases of the mango, avocado, and citrus fruits to determine the causal relations of *Colletotrichum gloeosporioides* Penz., *Gloeosporium limetticolum* Clausen and possibly other species of fungi to these diseases.

The diseases known as blossom blight, leaf spot, and fruit rot of the mango (*Mangifera indica* L.) have been reported to be caused by the fungus *Colletotrichum gloeosporioides* Penz. by Bessey **(1)**, Cardin **(3)**, Fawcett **(15)**, Mc Murran **(25)** and others **(7, 27, 38)**. Higgins **(19)** reports mango blight in Hawaii caused by a species of Colletotrichum. However, Nowell **(26)** says that the fungus is usually known as *Gloeosporium mangiferæ* Henn., but that it has also been known as *Colletotrichum gloeosporioides* Penz. Again Cook **(10)** and Fawcett (1. c.) hold that blossom blight is caused by *Gloeosporium mangiferæ* and Stevens **(35)** reports the same fungus on mango leaves.

A similar disease is found on the avocado (*Persea Persea* L). A species of Colletotrichum has been found to cause black spot and has been isolated from the tissues of diseased fruits, stems and twigs. The identity of this fungus with *Colletotrichum gloeosporioides* has been maintained by different writers **(10, 26, 27** and **37)**.

The wither-tip, blossom blight, and fruit canker of the limes has been studied thoroughly along with the wither-tip, spotting of leaves and fruit, and streaking of the fruit of other citrus trees, *i. e.*, pomelo and orange. Hume **(20)** and Massee **(24)** give information concerning the anthracnose of the pomelo; Cook **(8)** reports *Colletotrichum gloeosporioides* as causing the anthracnose of citrus fruits including the lime. Duggar **(11)** and Rolfs **(29)** sustain the same view as Cook as to the host relations of the pathogenes. Clausen **(5)** finds that *Colletotrichum gloeosporioides* is not responsible for the wither-tip of the lime. He studied and described another organism, *Gloeosporium limetticolum*. It appears from his and later investigations by Fulton **(7)** that the true pathogene of the lime is *Gloeosporium limetticolum*, while *Colletotrichum gloeosporioides* is

restricted to other hosts, especially citrus fruits other than lime, and further that it is not an active pathogene. Fawcet **(16)** separates the two pathogenes in like manner. Cook (1. c.) in 1906 advanced the statement that "the fungus which has been grown in pure cultures proceeding from these large spots on the leaves is not the same as that which we obtained from the withered leaves of the lime." Nowell (1. c.) believes that *C. gloeosporioides* is a weaker parasite than *G. limetticolum*. Furthermore, he dwells upon the fact that the former partakes mainly of the nature of a saprophyte. The same position has been taken by Thomas **(42)**.

In the opinion of the writer, *Colletotrichum gloeosporioides* Penz is the cause of the anthracnose of the mango, orange, pomelo, lemon, avocado and may be the cause of the wither-tip of limes.[1] Again we have found *Colletotrichum gloeosporioides* causing the lime wither-tip only in a few cases, while *Gloeosporium limetticolum* occurs more frequently especially in fruit spots. In this way we have verified Clausen's (1. c.) and Fulton's (1. c.) findings and conclusions that *Gloeosporium limetticolum* is an active pathogene of the lime. However, we differ from their views and also the views of Winston **(44)** as to the pathogenicity of *Colletotrichum gloeosporioides*. Quoting Fulton: "Winston, in connection with his studies of citrus tear stain, was unable to find, among numerous strains of *C. gloeosporioides* tested, any indication of active pathogenicity on very young fruits of various citrus species." We found during the past year a heavy shedding of the young fruit of lemon, orange, and pomelo. The cause for a considerable part of this shedding was found to be *C. gloeosporioides*. All strains from the hosts used in this investigation were obtained from such fallen small fruits. Thus, our position, in this question will be that *C. gloeosporioides* is, at least under Porto Rican conditions, an active pathogene.

A brief history and discussion of the diseases are given in this paper and cross-inoculation experiments and cultural characteristics are presented in detail.

PART I

HISTORY AND DESCRIPTION OF THESE DISEASES

Anthracnose of Citrus Trees other than Limes. (*Colletotrichum gloeosporioides* Penz.)

The causal fungus was first studied and described by Penzig in 1882. In 1904, Rolfs **(29)** described the disease from Florida. In

[1] This opinion is based on the studies of Porto Rican material with reference to the published literature and not on the examination of the type material.

1909, it was reported from Porto Rico by Fawcett **(14)** and in the same year, by Essig **(13)** from Santa Paula, California. Other reports record the disease in Cuba, Australia, Italy, Malta, Jamaica, Mexico and Brazil.

The disease occurs as a fruit and leaf spot, fruit drop and as a wither-tip of twigs. The symptoms are like those of the lime anthracnose except for the fruit and leaf spot. Spots of leaves occur only on debilitated or weak parts of the tree and only on old leaves. Fruit spots are to be found when the fruit has been bruised or injured. The fungus will enter through wounds and in moist weather particularly will produce a rot which progresses rapidly into the core resulting in a blackening of the tissues and seeds. The spots grow to be 5–6 cm. in diameter. The color of the spots is at first fleshy but later changes to a mummy brown or a chestnut brown.

This fungus in Porto Rico was found to be the cause of a heavy drop of the young fruits of the orange, pomelo and Chinese dwarf lemon, when ¼ to 1 or 1¼ inches in diameter. The drop occurred during the month of May and was especially destructive in the vicinity of the Station and in the Bayamón district. The conditions prevailing at the time were warm weather with heavy rains. The young fruit when gathered from the ground showed a distinct browning at the stem end. When cut longitudinally the inside was found to vary from a fleshy to brown color and this coloration marks the progress of the fungus outward to the blossom end. The fungus has been isolated from bits of the tissues of the inside of orange, lemon, and pomelo fruits exhibiting these symptoms. The fungus was also found on grapefruit flowers which had dropped to the ground and on the spurs from which the fruits had fallen.

Anthracnose of Limes.

Nowell **(26)** reports that an epidemic of the fungus *Gloeosporium limetticolum* occurred in Trinidad in the months of July and August, 1918. From that time the disease spread, resulting in a failure of the lime industry there. The disease also occurs in British Guiana and in 1919 Nowell found the fungus on material sent from there. He also gives account of the appearance of the disease in Dominica in 1922. Other reports show it to be present also in Cuba, Jamaica, Australia, Italy, Brazil, Malta and Mexico but it has not been found in California.

The fungus attacks tender foliage, blossoms and fruits. On young shoots the disease commences on the unopened whorl of leaves which

soon die, and from there progresses down for 3.5 or more centimeters. In our inoculations on small seedlings we have observed a similar effect. Fruiting bodies of the fungus appear rapidly on the surface of dead twigs under favorable moisture conditions, thus furnishing a constant source of inoculum.

On the inflorescence the disease may be described as follows: On unopened buds small brown discolorations appear. These grow in all directions and ordinarily cause the falling of the buds before they open. On expanded flowers the characteristic discolorations occur on petals, stigmas and styles but are most common on the stigmas (see fig. 2). There is much shedding of young fruit and in badly infested trees it is very seldom that we find healthy fruit.

Fruits that survive the period of greatest danger of infection may be attacked later. Cook and Horne **(9)** stated that infection of sour lime did not take place after the fruits were well set and Clausen **(5)** supports the same view. We have covered flower clusters with paper bags before the opening of the flower buds and when the fruits were about one-half or three-fourths of an inch in diameter the bags were removed. The fruit which appeared healthy was thus exposed to inoculation. Later observations showed that more than 50 per cent of such fruits took the disease, the cankers being produced as under normal conditions except that they were smaller. In that case circular to oblong spots which vary in size from 1–3.5 cm. $\times$ 2 cm. appear on the surface. At first the spots are brownish but with increasing size and age they turn to a fleshy color and the skin of the fruit is ruptured or cracked in many places, producing the characteristic cankers. In some cases the cracking is so pronounced and rapid that it includes a part of the adjacent healthy tissues. This cracking may occur in two directions but ordinarily, in one. It is not uncommon to see the fruit split along its whole length or width. The writer has seen some cases in which the rupturing of the skin or rind has progressed in both directions along the same path; *i. e.*, a longitudinal rupture has turned to the side and worked its way transversely, or vice versa, making a circular split around the fruit. The vesicles of the fruit are exposed on rupturing of the rind and carpel membrane, and there always seems to occur an abnormal enlargement of the same. There is also a gumming exudation.

Mango Anthracnose.

The first report of a mango blight appears to have been made

by Cobb. **(6a)** in 1894. The symptoms of the disease are spotting of the leaves and fruit and a blighting of the blossoms. The spots on the leaves range from 5–10 × 7–25 mm. Some of them extend from the margin, between the main veins, toward the midrib. In some instances two or three spots coalesce, forming irregular areas. It appears that the fungus starts growing on both sides and midway between the midrib and the margin of the blades. The spots increase in size and extend to the margin. The center of the spot is ochraceous-orange[1] at first, becoming cinnamon-rufous with age. This particular spotting has been found in only one instance. On the fruit the disease appears as very small brown spots. These spots enlarge very soon, especially under moist conditions. With the increase in size of the spots there is an intensification of their color to almost black and splitting or cracking of the rind and a sinking of the affected area included in the spots. The spots very often coalesce, forming large irregular areas which sometimes cover the entire rind of the fruit. The spots are commonly found at or around the stem end region. Streaking is seldom observed in Porto Rico. The damage done to the fruit is very great and this seems to be true in other places.

The blossom blight is particularly destructive in this Island. The fungus attacks open flowers and young flower buds and may result in the destruction of the panicles. Various writers have established a definite relation between weather conditions and the damages done by the disease on the blossoms. Collins **(7)** from Porto Rico and Higgins **(19)** from Hawaii state that the heavy rainfall together with a continued cloudy, wet weather, are responsible for a small crop of poor quality mangoes. The same seems to be true in Guatemala and Mexico. In this connection, Nowell **(26)** says that with blossom blight "the loss may be small or may be great according to the conditions prevailing".

McMurran **(25)** says: "The production of good crops of mangoes in Florida and throughout tropical and subtropical zones generally is very definitely related to the weather conditions at blooming time. Large crops cannot be expected when the weather at this time is moist and showery. This may be due to some extent to imperfect pollination, but the trouble is chiefly caused in Florida by the anthracnose fungus (*Colletotrichum gloeosporioides*)." Our observations lead us to support that view.

[1] Color characters throughout the paper are based on Ridway's "Color Standards and Nomenclature".

Avocado Anthracnose.

The first report of the disease seems to be from Cuba by Cook.[1] Rorer **(30)** reports it from Trinidad in 1910. Later reports come from Porto Rico by Stevenson **(38)** in 1918, and from Florida by Stevens **(37)** in 1922. The disease appears as a blossom blight, fruit rot and a leaf spot. The effects and appearance of the disease on avocado blooms is similar to those of the blossom blight of the mango. Small black spots or specks appear on the small flowers and result in their dropping. Flowers may also have their growth retarded and the young fruits may shed later. Blossom blight seldom occurs in Porto Rico. The shedding of the blossoms is almost entirely due to imperfect pollination.

On the fruit the symptoms of this disease are as follows: Spots appear over the surface as small light-brown discolorations of the skin of the fruit. They enlarge very rapidly, the color at the same time changing to olive-brown or black. This color corresponds to older growth while the younger growth (one-day old) is marked by a very light-brown ring or outer progressing zone. The fungus penetrates into the flesh and may even extend to the seed, which remains unaffected. There is a marvelous rapidity of rotting which makes the fruit useless. Our experiments with ripe and unripe fruit indicate that the fungus grows very slowly until the fruit begins to ripen. Inoculated unripe fruit is apparently unaffected until it begins to ripen; it is then destroyed in a very few days. The writer has found that the rotting is very prevalent in the market on fruits from which the stem has been removed. The Porto Rican farmer is not careful in the picking of the fruit, which he does by shaking the tree. This method gives many chances for inoculation of the fruit through wounds.

The symptoms of the disease on Guatemala varieties grown in Porto Rico are as follows: Small brown spots appear over the surface of the fruit. These spots grow slowly on unripe fruit, but on ripe fruit they enlarge and become sunken and black; cracking of the skin may occur around the spots. If a fruit is opened, making the cut through a spot, the rotting will be seen to have progressed more deeply in the center of the spot than on the sides, thus resulting in a concave rotted region. The cracks which result from the invasion of the fungus hyphæ open the way for the entrance of saprophytes which greatly aid in a rapid destruction of the fruit.

[1] Dr. Mel. T. Cook has stated personally to the writer that he found the disease in Cuba during his stay at the Estación Central Agronómica in the years 1902–1904.

PART II

CROSS-INOCULATION EXPERIMENTS, CULTURAL CHARACTERISTICS, AND MORPHOLOGY OF THE PATHOGENES

Cross-inoculation Experiments.

Inoculation experiments have been conducted by various workers on different anthracnose organisms. Stoneman after working with anthracnoses **(41)**, says that we must not depend too much upon results from cross-inoculations in the laboratory, since, under the conditions prevailing, the hosts act as culture media. Cobb **(6b)**, Laubert **(22)** and Shear and Wood **(31)** are of the opinion that anthracnose fungi adapt themselves to a wide range of conditions. This makes careful experimentation necessary in order to make sure of the relations existing between the hosts and the parasites. Toro **(43)** conducted detailed studies with *Glocosporium musarum* Cke. & Mas. and arrived at a similar conclusion.

The writer has performed inoculation experiments with the various organisms on different hosts under laboratory and field conditions. The organisms were isolated from the different hosts and each was designated according to its host; *i. e.*, the anthracnose fungus from the orange was marked, thus, *O;* that from the pomelo, *P;* that from the avocado, *Av.;* from the mango, *M;* from the lime, *L;* and from the lemon, *Le*. As there were a number of cultures from each host, the culture number was given after the corresponding host. Thus *Le 1* was used to signify culture No. 1 from the lemon; *L 1* to mean culture No. 1 from the lime; *O 1*, culture No. 1 from the orange, etc. The source of all cultures is as follows: M 1–M 15; and M 22–M 30 from ripe mangoes (native and imported varieties) from various places on the Island; M 16–M 21, from blighted blossoms; P 1–P 7, young dropped pomelo fruits; P 8–P 10, pomelo flowers; O 1–O 10, young fallen orange fruits; Le 1–Le 5, young fallen lemon fruits (Chinese dwarf lemon); L 1, L 2, L 3, L 22, L 24–L 26, from lime fruit spots or cankers; L 4, L 5, L 19, L 21, from lime withered twigs; L 6, L 7, L 8 and L 14–L 18, from lime leaf spots; L 9–L 13, from lime thorn spots; and L 23, from lime withered twigs from inoculation with L 3.

Isolations were made from fruit spots and rots mainly, in the case of citrus hosts; however, isolations were also made from the withered tips of twigs, spotted leaves and blighted blossoms of citrus and from blighted mango blossoms as well.

In the fruit-inoculation experiments, all fruit were first washed

in a 1: 1000 mercuric chloride solution and finally with sterile distilled water and then placed in moist chambers, which had been washed in the same solution. Needle-prick inoculations were practiced. All trials were made in triplicate. The results are given below:

Inoculations on Ripe Mangoes.—Inoculations with all cultures from mango, pomelo, orange, lemon and lime 1, 3, 9–12, and 23 produced large brown to black spots, characteristic of the disease on mango. All cultures from the lime except those given above produced slight discolorations of the tissue around the point of inoculation but these discolorations were not characteristic of the disease on mango.

Inoculations on Avocados.—Inoculation on ripe fruits with Av. 1; M 17, 18 and 20; P 1; O 1; and lime cultures Nos. 1, 3 and 23, produced mummy-brown discolorations of the skin and rotting of the fruit. The same cultures when green fruits were inoculated did not show any effects until the fruits began to ripen. Inoculations with lime cultures Nos. 2, 24, and 26 on both ripe and green fruits produced a slight discoloration around the point of inoculation.

Inoculations of Lime Twigs.—These twigs were inoculated with spores from natural lesions and with spores from cultures. The inoculations were made from a spore dilution in water applied to the twigs with an atomizer or a camel's hair brush. Some of the twigs were injured and others were left uninjured. They were covered with manila bags. A fine mist of sterilized water was sprayed into all the bags every day after 5 p. m. The inoculations were made with spores from acervuli on mango, avocado, pomelo and lime. Also with spores from cultures grown from acervuli on mango, avocado, and pomelo; also with spores from the acervuli on lime; spores from the lime cultures 1, 2, 3, 23 and 24. All the above inoculations on lime twigs produced wither-tip and leaf spot.

Inoculations of Lime Fruits.—The lime fruits were inoculated with the same organisms and in the same manner as the lime twigs. The results in all cases were negative except in the case of fresh spores from the lime and those from culture L 2 and L 24 in which cases small, cankerous spots were produced.

Inoculation of Pomelo Seedlings.—These seedlings were inoculated in the same manner and with the same organisms as the preceding. In all cases a wither-tip and leaf spot were produced except when the fresh spores direct from the lime and those from cultures L 2 and L 24 were used; in which cases there was no reaction.

On Mango Twigs.—Needle-prick spore-spray inoculations were

made on the unopened buds of a new growth, and during rainy weather which insured a rapid growth of the host. Spores were used from acervuli on avocado, mango, and pomelo, from cultures of L 1, L 3, L 23, and L 2, L 24 and L 26.

The effect of all inoculations except those with L 2, L 24, and L 26 was as follows: Rapid dying of the young twigs causing small leaves of the young buds to shed comparatively early. Ten days after inoculation, the dying of the twigs had progressed downward about 3 cm. Infection is first manifested by slight browning or darkening of the adjacent tissues, then the twigs turn black (see fig. 3). The results with L 2, L 24 and L 26 were negative.

On Avocado Twigs.—The same general plan of inoculation and with the same organisms was followed as with mango twigs. All inoculations showed negative results.

SUMMARY CONCERNING THE RESULTS OF INOCULATIONS ON POMELO SEEDLINGS, LIME TWIGS, LIME FRUITS, MANGO TWIGS, AVOCADO TWIGS, RIPE MANGOES, AND GREEN AND RIPE AVOCADOS

The results on these hosts tend to separate the cultures used in the foregoing inoculations into two groups: *Group I*, consisting of all cultures from the avocado, mango, pomelo, possibly orange and lime cultures Nos. 1, 3 and 23; *Group II*, consisting of cultures L 2, L 24 and L 26.

It was especially noticeable that cultures which produce the anthacnose of mango, avocado, orange, pomelo, and some producing wither-tip of the lime in nature, were not able to produce the lime fruit spot or canker. This peculiar characteristic makes the above separation into groups more important. It is also apparent that these anthracnose-producing fungi have no effect on avocado twigs. Mango twigs when tender seem to be susceptible to the attack of *Colletotrichum gloeosporioides*. At least, this appears to be true under experimental conditions.

Cultural Characteristics.

The writer has made a careful study of the comparative behavior of the fungi under consideration on different media. A large variety of media have been carefully prepared and used in this work. All sugar media used were sterilized in the Arnold steam sterilizer; all other media in the autoclave at 20 pounds pressure for 30 minutes. Only 10 c.c. of the medium was put in each tube. All petri plates used were of the same size. All plates were poured the day previous

to inoculation. Inoculations were made during the morning. They were made in triplicate for each culture and the tests were twice repeated. Growth was measured in centimeters in diameter at the end of seven days for solid media in petri plates. For liquid media growth was estimated by rapidity of growth and character of the substratum. Color changes were carefully noted and recorded. The results are given in the following pages. Tables and plates are here presented.

Rate of Colony Growth.

The growth of the colonies of each culture on 2 per cent nutrient glucose, 2 per cent nutrient saccharose, 2 per cent nutrient lactose, 2 per cent nutrient-dextrine, oat-meal, wheat-flour, and corn-meal agars was measured at the end of seven days and the results given as centimeters in diameter of colonies.

For convenience, all cultures from each host exhibiting a close relation in size in diameter of colony were grouped together. Table I includes the maximum, mean and minimum sizes of each group of colonies.

From an examination of Table I, it will be seen that there is a very sharp line of demarkation between Group 6, which includes cultures L 2, L 4–L 8, inclusive, L 14–L 22, inclusive, and L 24–L 26; and all other groups under which all mango, avocado, pomelo, lemon, and orange cultures with L 1, L 3, L 9–L 13, inclusive, and L 23 cultures. Thus, the means in all media for Group 6 run from 4.255 to 4.96 cm. in diameter and minimum growth was 4 to 4.80 cm. with the maximum growth being 4.40 to 5.60 cm. in diameter; while measurements for the other groups taken as a whole are: mean, 6.28 to 8.04; minimum, 5.0 to 8.0, and maximum, 7.0 to 8.5 cm.

Therefore on the basis of colony size we will place tentatively, all cultures of Group 6, under one species and call it *Gloeosporium limetticolum* Clausen, including cultures L 2, L 4–L 8 inclusive, L 14–L 21, inclusive, L 22, L 24–L 26 inclusive, and also L 4–L 8 inclusive. This will constitute *Main Group I.* All other cultures (L 1, L 3, L 23, all mango cultures, all avocado, pomelo, orange and lemon cultures) under another species *Colletotrichum gloeosporioides* Penz. This will be *Main Group II.*

Growth characters (size of spores, zonation, color of both culture and substratum, character of mycelium, etc.) of all cultures have been carefully observed with special reference to color behavior, on

2 per cent glucose-nutrient agar, 2 per cent saccharose-nutrient agar, 2 per cent dextrine-nutrient agar, oat-meal agar, and corn-meal agar.

We have worked with carbohydrate media mainly since these afford a good working basis for the separation of strains and even species. Ravn **(28)** in studies on the genus *Helminthosporium* finds a relation between carbohydrate nutrient and blackness of the fungus. Stevens and Hall **(34)** have found good data on other fungi to support this view. Color phenomena in fungi have been studied and discussed in several papers by Smith **(32)**, Stewart and Hodgkiss **(40)** and Hedgecock **(18)**. Relation of carbohydrate nutriment to color has also been established by Stevens **(36)**. He found in his studies on *Helminthosporium* that the colony changes black in the region of the carbohydrate.

In our studies green or olive and brown discoloration of the substratum has been observed with a large number of cultures of the mango, avocado, orange, lemon, pomelo and a few of the lime cultures (*Colletotrichum gloeosporioides*). Most cultures from the lime pathogene (*Gloeosporium limetticolum* Clausen) show a light salmon-orange to apricot-orange or colors approximating these.

An attempt has been made to simplify the rendering of the results giving them in tabular form. All cultures which are alike in their effects on the media were grouped together in each particular medium. In this way differences between cultures are easily noted and the separation of the two species *C. gloeosporioides* Penz. and *G. limetticolum* Clausen is made possible without great difficulty. The results are given for the glucose and corn-meal agars, in Tables II and III. The results and observations on the other media are omitted for brevity.

Cultures which on one medium fall under a certain group may belong under another group for some other medium. The relation between cultures which belong under the same species is thus established.

It is striking that cultures of *C. gloeosporioides* from mango, avocado, orange, pomelo, lemon and lime (Nos. 1, 3, 9, 10, 11, 12, 13 and 23 cultures) differ so much in cultural characters from those of *G. limetticolum* Clausen (lime cultures Nos. 2, 4, 5, 6, 7, 8, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26). A similar difference has been previously pointed out in relation to colony size.

Color behavior, character of mycelium and character of substratum of all mango, pomelo, orange, lemon and a few lime cultures Nos.

1, 3, 9, 10, 11, 12, 13, 23) are more or less similar. The avocado group is different. Our studies with the avocado cultures have not been very extensive, and therefore we are leaving them under the species *Colletotrichum gloeosporioides* Penz. Lime cultures Nos. 2, 4, 5, 6, 7, 8, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25 and 26 maintain a close relationship in the different characters of growth and development. The most peculiar character is the scanty mycelium in most of them.

The size of the acervuli is almost constant for the cultures of each species. The number of acervuli varies with the different cultures with both *C. gloeosporioides* and *G. limetticolum*. The acervuli of the former species are larger than those of the latter.

On the basis of growth character discussed above we are holding Clausen's **(5)** division into two species to be correct. Of greatest importance are the following characters: *Colletotrichum gloeosporioides*: aerial mycelium white or dark, profuse, sometimes fluffy; of rapid development; acervuli numerous in most strains, large; substratum brown, green or olive or shades of these two latter colors. *Gloeosporium limetticolum*: mycelium scanty in most cultures, white; acervuli small, numerous in most strains; substratum light salmon-orange or apricot-orange.

Effect of Reaction.

All cultures were grown in bouillon of different acid and alkaline concentration; *i. e.*, +40, +45, —40, —45, Fuller's scale. The same general method as for solid media was followed; *i. e.*, triplicates of each culture on every medium. The tests were made twice.

Growth was recorded at the end of ten days and the rate or amount of growth given as + + +, + +, +, + —, and no growth. Much growth was expressed by + + +, fair growth by + +, some growth by +, and very little growth or slightly noticeable was expressed by + —. The results are presented in Table IV. The +45 concentration is deleterious to all cultures and —45 to all except the avocado cultures. The *G. limetticolum* cultures do not grow in any of the four concentrations, so it seems probable that they must cease development at lower concentrations. The *C. gloeosporioides* cultures from the mango produce a fair growth in the +40 concentration, and those from the pomelo, orange, lemon, avocado and lime (L 1, L 3, L 9–L 13 inclusive, and L 23) some growth. Here again we have been able to verify Clausen's conclusion that there are two different species.

Size of Spores.

To throw more light on the differential behavior of the different cultures as influenced by different nutrients, comparative measurements were made of spores from seven-day-old cultures in various media and from natural sources.

Five hundred spores from each culture on glucose agar were measured for their lengths and widths. The spore-length table is omitted as a matter of brevity.

A constant variation was found in length of spores of the different cultures while the margin of the width differences was very narrow. From our results it appears that spore size is not a very reliable basis for the determination of species. However, Toro **(43)** in his studies on banana anthracnose distinguishes eleven strains of *Gloeosporium musarum* Cke. & Massee on the basis of spore size. Burger **(2)** finds differences in strains of *Colletotrichum gloeosporioides* Penz. in regard to spore size. The same relation is established by La Rue and Barlett **(21)** with *Pestalozzia guepini* Desm., Stackman and Piemeisel **(33)** with *Puccinia graminis* Eriks. & Hern., Leach **(23)** with *Colletotrichum lindemuthianum* (Sacc. & Magn.), Brios and Cav. and Christensen **(4)** with *Helminthosporium sativum* (Pammel), King and Bakke.

Mean length of spores of cultures of *Colletotrichum gloeosporioides* and *Gloeosporium limetticolum* on glucose agar are shown in Table V.

There is a range of 14.32 $\pm$ 0.023 to 22.51 $\pm$ 0.0798 microns. This means that with the former there is a wider range of mean length than with the latter and at the same time the shortest lengths are met with in *Gloeosporium limetticolum* cultures.

It was found that many cultures approached each other in mean length of spores, which made it possible to classify them into groups on the basis of mean spore length. Table VI shows the classification.

It was also noted that there were many cultures with the same modal lengths so a classification was prepared on this basis. This classification is given in Table VII.

The range of variability of spore lengths of a large majority of the cultures, judging from the preceding tables, is not very great and a correlation between this character and that of cultural characteristics and host behavior has not been established.

Burger **(2)** in his investigations of variation within *Colletotrichum gloeosporioides* found that many strains had the same mode for their spore lengths. Our findings verify this conclusion and at the same

time prove that variation also exists in the fungus *Gloeosporium limetticolum*. Cultures of *Colletotrichum gloeosporioides* maintain a similar relation toward cultures of *Gloeosporium limetticolum*. Thus, L 1 which falls under the *C. gloeosporioides* group has the same modal length as L 2 of the *G. limetticolum* group, as shown by Table VII. Likewise, L 23, L 9–L 13 inclusive, have the same mode as L 14–L 21; the former belonging to *C. gloeosporioides* and the latter to *G. limetticolum*. The same relation exists between the cultures of *C. gloeosporioides* from different hosts as that occurring among individual cultures from the same host.

Effect of Medium on Spore Length.

In the study of the effect of media on the cultures it was soon observed that variability exists according to the medium. Spore length measurements were made from four media by the general plan followed in the preceding chapters, and the mean lengths calculated (see Table VIII).

The greatest mean length seems to occur on the dextrine and glucose agars for most cultures. The lowest mean lengths appeared on the saccharose and oat-meal agars. From these results it might appear that on starch media the spore length is shorter. However, we do not have enough evidence at hand to arrive at a definite conclusion.

Lengths of Spores in Nature.

Spores were measured from fruiting masses or acervuli on mango blossoms, mango fruits, avocado fruits, lime thorn spots, lime leaf spots and lime twigs (see Table IX).

The length of spores from mango blossom varies from 13.19 to 19.04 microns with a mean of 16.87 $\pm$ 0.036 microns. The range of variation of spores from the fruit is wider than that of those from blossoms and the mean length is greater. The spores from the avocado have a minimum length falling under the range of minimum lengths of spores from the lime. The upper range or maximum length of spores is greatest for the spores from the lime twigs and leaf spots.

The measurements of spores obtained from pustules on lime thorns show some similarity to those of the spores from the mango and the avocado. This is further evidence that spotting on lime thorns is frequently caused by the fungus (*C. gloeosporioides*) causing the anthracnose diseases of those fruits. Our previous experiments and observations with cultures L 9–L 13 inclusive, obtained from lime thorn spots, show similar results.

Variation of Spore Widths.

The range of variability in width of spores was not so great as that for the lengths. See Table X. There is a constant, although not great variation in the mean width of the various cultures. However, the minimum and maximum widths are common for a large number of cultures.

MORPHOLOGY

Occurrence of setae.

Setæ have been but rarely found under natural conditions. They were observed on blighted mango blossoms kept in a moist chamber and on citrus leaves, but not on lime fruits. Most cultures of *C. gloeosporioides* produced setæ in carbohydrate media while no setæ were ever produced by cultures of *Gloeosporium limetticolum* under similar conditions.

Rolfs **(29)** reports setæ of *C. gloeosporioides* on oranges but says that they are frequently absent on tender lime twigs, and on "lime fruits usually absent". Clausen **(5)** uses the absence of setæ in the pathogen to distinguish lime wither tip from that of other citrus fruits. Nowell **(26)** takes a similar position. Our observations prove that the absence or presence of setæ will vary with the environment, and while not attaching much reliability to this characteristic, we are inclined to support Clausen's **(5)** conclusion. Stoneman **(41)**, Edgerton **(21)** and Shear and Wood **(31)** hold "That the setæ are variable as to presence or absence and that they are not reliable morphological characters to use in separating genera."

Conidiophores and Conidia.

All cultures of *G. limetticolum* develop conidiophores which are light or almost hyaline, those of cultures of *C. gloeosporioides* are slightly darker. Conidiophores from the avocado cultures of *C. gloeosporioides* seem to differ somewhat from those of the other cultures in shape and slightly in size and color. They are as a rule very light in color and broad at the middle with constrictions on both sides of the broad portion frequently occurring, and with pointed ends or even bases. They may be smaller than the conidiophores of the other cultures (see figs. 19, 20 and 21).

Clausen **(5)** uses the shape of spores as a strong point in distinguishing *G. limetticolum* fram *C. gloeosporioides.* He describes the spores of the two species as follows:

"The conidia of the common wither-tip fungus have a peculiar very characteristic form. Typically one end is rather rounded, the other end is blunt, but

more or less obliquely truncate, and there is slight constriction at the middle of the spore. The conidia of the pathogenic fungus have one or both ends more or less pointed with very little tendency toward constriction at the middle."

We have not found such differences existing between them on either spores from the natural source or those from cultures. The blunt end of the spores is just as true of *C. gloeosporioides* as of *G. limetticolum* (see figs. 8 and 9), and cases of the two ends being pointed have been found in both species (see figs. 12 and 13). Constriction of the spores although not frequent, occurs with both species (see figs. 10 and 11).

Vacuoles are more numerous and larger in the case of *G. limetticolum*, especially is this true of spores from cultures (see figs. 14 and 16). The medium seems to have an important relation on spore shape and form. All forms have been noted with both *C. gloeosporioides* and *G. limetticolum* in different media. Some are constricted at various places, others are very long and thin, while others are short and wide. Still others are very wide at one end and very narrow at the other, being more or less flask-shaped (see figs. 17 and 18).

The character of conidia still remains a rather doubtful or confusing basis in the distinction between *Colletotrichum gloeosporioides* and *Gloeosporium limetticolum*.

SUMMARY AND CONCLUSIONS

(1) *Colletotrichum gloeosporioides* Penz. appears to be the cause of the anthracnose diseases of mango, orange, grapefruit, lemon, avocado, and sometimes of lime.

(2) Lime wither-tip may be caused by either *C. gloeosporioides* or *Gloeosporium limetticolum* Clausen.

(3) *Colletotrichum gloeosporioides* Penz. frequently causes spotting of lime blossoms and the wither-tip. It is also the cause of the spots on lime thorns. The latter is demonstrated by cultures L 9–L 13, inclusive, which behaved like other *C. gloeosporioides* cultures and very distinct from cultures of *G. limetticolum*.

(4) *Gloeosporium limetticolum* Clausen is the cause of wither-tip and leaf spot of limes.

(5) *G. limetticolum* appears to be the only cause of fruit canker or fruit spot of limes.

(6) Under artificial conditions the various cultures of *C. gloeosporioides* and *G. limetticolum* exhibit distinct cultural characteristics.

(7) Cultures from the avocado differ somewhat from cultures obtained from other hosts in cultural characteristics. The difference may not furnish enough evidence for their separation into a new species.

(8) There are such differences between most cultures from the lime and all cultures from the other hosts that Clausen's **(5)** separation of the former into a distinct species appears to be justified.

(9) The four most salient growth characters in which cultures of *C. gloeosporioides* varied from cultures of *G. limetticolum* or such cultures among themselves are: (*a*) size, number, and arrangement of acervuli; (*b*) color of acervuli and substratum; (*c*) character of aerial mycelium; (*d*) size of colonies.

(10) *C. gloeosporioides* can resist slightly more acid or alkaline concentrations than *G. limetticolum*.

(11) Setæ are occasionally present in *C. gloeosporioides* and absent in *G. limetticolum*.

(12) Variation in spore size is induced by the culture medium.

(13) There is great morphological similarity between *G. limetticolum* and *C. gloeosporioides*.

(14) Environment induces variation in form and shape of spores.

(15) The character of conidia appears to be rather uncertain for distinguishing between *Gloeosporium limetticolum* and *Colletotrichum gloeosporioides*.

The writer wishes to acknowledge his deepest appreciation to Dr. Mel. T. Cook, Chief of the Division of Botany and Plant Pathology, under whose direction this work has been conducted; whose never-failing encouragement and advice together with much valuable and helpful criticisms and suggestions have made the preparation of this paper possible.

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TABLE I

Separation of Cultures of *C. glocosporioides* and *G. limetticolum* on the Basis of Colony Size in Centimeters in Diameter, at the end of seven days

Cultures in Each Group	2% Glucose agar			2% Sacc arose agar			2% Dextrine agar			2% Lactose agar			Wheatmeal agar			Cornmeal agar			Oatmeal agar		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum
I– M 1 - M 30.	6.0	7.08	8.0	6.7	7.61	8.2	5.5	7.12	8.0	6.0	7.53	8.2	5.9	7.43	7.9	6.1	7.19	7.6	5.8	7.24	8.0
II– P 1 - P 10.....	6.0	6.89	8.0	6.8	7.24	7.8	5.8	6.90	7.8	5.0	7.18	8.0	7.0	7.60	7.8	7.0	7.74	8.0	7.0	7.36	7.7
III- O 1 - O 5.	7.0	7.32	7.6	7.0	7.40	7.6	7.0	7.84	8.5	7.0	7.20	7.5	6.5	7.32	7.8	7.8	7.90	8.0	6.0	6.28	7.0
IV- Le 1 - Le 5	7.8	7.98	8.1	8.0	8.02	8.1	7.7	7.92	8.1	7.8	8.04	8.2	7.5	7.74	7.8	7.8	8.00	8.2	7.8	7.80	7.8
V– L 1, L 3, L 9, L. 13, y L 23.....	7.3	7.75	8.0	8.0	8.10	8.3	7.1	7.75	8.0	7.4	7.90	8.1	7.7	7.86	8.0	7.8	7.95	8.0	5.2	7.63	8.0
VI- L 2, L 4, L 8, L 14, L 22, L 24 y L 26.....	4.0	4.71	5.0	4.1	4.87	5.1	4.1	4.25	4.4	4.0	4.49	5.1	4.2	4.85	5.0	4.8	4.96	5.1	4.1	4.68	5.6
VII-Av. 1 - Av. 6	7.7	7.75	7.8	7.8	7.98	8.2	7.5	7.60	7.7	7.0	7.13	7.3	7.3	7.36	7.5	7.4	7.47	7.5	7.6	7.73	7.8

TABLE II

Characters of Growth of All Cultures on 2 Per Cent Nutrient Glucose Agar. The cultures arranged into groups according to character of growth.

GROUP I M 1, M 2, M 3, M 4, M 5, M 6, M 20, M 21, M 16, M 17.	Acervuli large, numerous, in zones; *brick-red* in color; substratum: zones of *dark greenish-olive* with some *brick-red* marks underlying the masses of acervuli; older growth underlaid by *mars brown* color; mycelium profuse in long threads; *white* in some colonies; *grayish* or *dark* in others.
GROUP II M 7–M 15, M 22–M 27.	Acervuli large, numerous, zoned or not, all shades of color from *yellowish olive* to *olive* or *dark-greenish*-olive. Brown spots underlie some of the acervuli masses. Aerial mycelium profuse, dull white to dark in color. In some colonies the acervuli are *salmon* in color with *brownish-olive* or mummy brown substratum.
GROUP III P 2, P 3, P 4, P 6, P 7, P 9, P 10.	Acervuli large, numerous, zoned or not, all shades of color from *light-ochraceous-buff* with *olive* markings to *ochraceous-buff* with substratum underneath the acervuli of a *cinnamon-rufous* color and *brownish-olive* in the inner zones. The medium under the old growth changes in some colonies to almost *dark brown* or *black*. Mycelium profuse, *whitish*.
GROUP IV P 1, P 8, P 5, O 1, O 3–O 5, Av. 6.	Acervuli large, numerous, zoned, *pale ochraceous-salmon*. Color of substratum underneath the acervuli is *ferruginous*. Concentric ferruginous markings on colony. Aerial mycelium profuse.
GROUP V O 2, LE 1–Le 5.	Acervuli large, numerous, zoned or not, *ochraceous-salmon;* substratum shows ochraceous-salmon discoloration and much cinnamon brown or even ochraceous buff with cinnamon-brown. Mycelium profuse, O_2 more profuse than the others.
GROUP VI L 5–L 8, L 22, L 24, L 25, L 4, L 2.	Acervuli small, numerous or few, not zoned, *light-salmon* orange, mycelium in form of very short whitish threads.
GROUP VII L 14–L 21,	Acervuli small, numerous, not zoned, substratum unchanged; *profuse*, dull white.
GROUP VIII L 3, L 23, L 1, L 9–L 13.	Acervuli large, numerous, more or less zoned, flesh color. Substratum: *ferruginous* to *Kaiser-brown* with *brownish-olive* zones or flesh-ocher. Aerial mycelium profuse whitish dull.
GROUP IX Av. 1–Av. 6.	Acervuli large numerous in old colonies, in young colonies only in central portion, *rufous*. Masses of spores borne on the aerial mycelium around the center of the colony are *grenadine pink* to *light-salmon-orange*. Acervuli zoned or not. Mycelium white (snow); profuse, *floccose*, the long tufts radially arranged. The power for mycelial growth is remarkable, the tufts reaching the top dish and spreading under it.
GROUP X M 18–19	Acervuli large, numerous, perfect zonation, *apricot-orange* in color. Nearly always have central portion of colony of a gray mycelium. Tufts of gray mycelium also occur throughout the young growth.
GROUP XI L 26.	Acervuli small; numerous, *apricot orange* in color; central portion of colony is *bluish-black*.

TABLE III

Growth Characters of All Cultures on Corn-Meal Agar. They are arranged according to these characters.

GROUP I M 7–M 11, L 13, L. 1.	Acervuli large, numerous, zonation not distinct, salmon; substratum: *dark grayish-olive;* mycelium white, dark or gray, profuse.
GROUP II M 10.	Acervuli large, numerous, *rufous* or *apricot-orange.* Substratum: rufous or apricot-orange along the edge of colony *dark grayish-olive;* mycelium fair, dark.
GROUP III P 1–P 4.	Acervuli large, numerous, ferruginous; substratum *greenish-olive;* mycelium moderate, white or dark.
GROUP IV P 5–P 10, O 1.	Acervuli large, numerous, *light salmon-orange* or *flesh-ocher;* mycelium scanty in some cultures, profuse in others.
GROUP V Le 1–Le 5.	Acervuli large, numerous, more or less zoned, *ochraceous salmon;* substratum: *ochraceous-salmon;* mycelium moderate to profuse, white (dull).
GROUP VI L 5–L 8.	Acervuli small, numerous, *not zoned,* flesh-ocher; substratum: *ocher-red;* aerial mycelium occurring as short threads, white.
GROUP VII L 9–L 12, L 22, L 24.	Acervuli large, numerous, slightly zoned, *flesh ocher;* substratum *flesh-ocher,* green under acervuli; aerial mycelium occurring as long threads.
GROUP VIII L 3, L 23.	Acervuli large, numerous, not zoned; *rufous;* in streaks over surface of colony. Substratum: rufous; mycelium little, white.
GROUP IX L 14–L 21.	Acervuli small, numerous, *no zonation, flesh ocher;* substratum: *flesh-ocher* to *ocher-red.* Small masses of mycelium, white.
GROUP X Av. 1–Av. 5.	Acervuli large, few, apricot-orange, for the most part in a large mass in the center of the colony, otherwise scattered in small numbers throughout the surface or in zones; substratum: surface line *dark greenish-olive,* more pronounced in some cultures than in others; mycelium either in the form of a large, white mass around the center of the colony or white, floccose, sometimes fluffy.
GROUP XI L 25, L 26.	Acervuli small, numerous, not zoned, flesh ocher, except a central green portion; substratum: *bluish* central portion, ocher-red outside it; aerial mycelium in form of very short threads.

TABLE IV

Shows Effect of Reaction. Growth on Bouillon of Different Acid and Alkaline Reaction

Culture	+ 40 Fuller's Scale	+ 45 Fuller's Scale	— 40 Fuller's Scale	—45 Fuller's Scale
M 1 - M 30.....	+ +	No growth	+	No growth
P 1 - P 10.....	+	No growth	+	No growth
O 1 - O 5.....	+	No growth	+ Salmon acervuli on the surface	No growth
Le 1 - Le 5.....	+	No growth	+	No growth
L 1, L 3, L 9, - L 13, L 23.....	+	No growth	+	No growth
L 2, L 4 - 8, L 14 - L 22, L 24 - 26.....	No growth	No growth	No growth	No growth
Av. 1—.Av. 6..	+	No growth	+ + + Large, numerous, submerged colonies	+ —

TABLE V

Shows Mean Lengths in Microns of Spores of Cultures of *C. glocosporioides* and *G. limetticolum* on 2 per cent Glucose Agar

Culture No.	Mean	Culture No.	Mean
M 1	14.85 ± 0.066	O 2	15.17 ± 0.041
M 2	15.57 ± 0.055	O 3	15.30 ± 0.072
M 3	15.55 ± 0.045	O 4	15.18 ± 0.075
M 4	16.23 ± 0.057	O 5	15.26 ± 0.037
M 5	16.06 ± 0.052	Le 1	14.97 ± 0.042
M 6	16.08 ± 0.080	Le 2	14.95 ± 0.056
M 7	19.25 ± 0.085	Le 3	14.55 ± 0.034
M 8	17.28 ± 0.095	Le 4	14.60 ± 0.047
M 9	16.70 ± 0.085	Le 5	14.32 ± 0.023
M 10	16.09 ± 0.067	L 1	14.55 ± 0.121
M 11	22.51 ± 0.078	L 2	14.36 ± 0.065
M 12	17.37 ± 0.064	L 3	15.25 ± 0.096
M 13	17.33 ± 0.075	L 4	15.85 ± 0.036
M 14	17.44 ± 0.061	L 5	15.63 ± 0.052
M 15	17.05 ± 0.066	L 6	15.89 ± 0.076
M 16	15.35 ± 0.080	L 7	15.84 ± 0.026
M 17	15.06 ± 0.040	L 8	15.35 ± 0.039
M 18	14.89 ± 0.047	L 9	16.18 ± 0.071
M 19	16.59 ± 0.069	L 10	16.12 ± 0.092
M 20	17.77 ± 0.066	L 11	15.13 ± 0.052
M 21	17.62 ± 0.061	L 12	14.86 ± 0.046
M 22	17.19 ± 0.036	L 13	15.23 ± 0.074
M 23	17.07 ± 0.075	L 14	15.92 ± 0.020
M 24	16.69 ± 0.065	L 15	15.29 ± 0.043
M 25	17.38 ± 0.053	L 16	15.08 ± 0.074
M 26	17.77 ± 0.050	L 17	15.71 ± 0.061
M 27	16.46 ± 0.059	L 18	15.93 ± 0.028
M 28	15.27 ± 0.098	L 19	16.41 ± 0.052
M 29	15.50 ± 0.067	L 20	16.74 ± 0.029
M 30	15.81 ± 0.032	L 21	16.86 ± 0.096
P 1	16.09 ± 0.054	L 22	14.99 ± 0.045
P 2	18.05 ± 0.050	L 23	15.00 ± 0.039
P 3	14.88 ± 0.028	L 24	15.30 ± 0.046
P 4	15.37 ± 0.030	L 25	14.02 ± 0.033
P 5	16.08 ± 0.046	L 26	14.17 ± 0.098
P 6	16.12 ± 0.037	Av. 1	16.89 ± 0.082
P 7	16.35 ± 0.095	Av. 2	17.33 ± 0.063
P 8	16.28 ± 0.045	Av. 3	17.73 ± 0.085
P 9	19.34 ± 0.062	Av. 4	17.94 ± 0.031
P 10	17.26 ± 0.054	Av. 5	16.64 ± 0.038
O 1	16.03 ± 0.047	Av. 6	16.57 ± 0.088

TABLE VI

Separation of Cultures of *C. glocosporioides* and *G. limetticolum* into Groups According to Mean Lengths of Spores in Microns

Group	Cultures	Range mean length in microns
I	M 1—M 3, M 16—M 18, P 3, P 4, O 2—O 5, L 1—L 3, L 5, L 8, L 11—L 13, L 15—L 17, L 22—L 24	14.85 —15.816
II	M 4—M 6, M 9, M 10, M 19, M 24, M 27, P 1, P 5—P 8, O 1, L 4, L 6, L 7, L 9, L 10, L 19—L 21	15.839—16.861
III	M 8, M 12—M 15, M 20—M 23, M 25, M 26, P 10, Av. 1—Av. 3	16.890—17.794
IV	Av. 4, P 2	17.94 —18.90
V	M 7, P 9	19.257—20.250
VI	M 11	21.50 —22.511

TABLE VII

Classification of Cultures into Groups According to Modal Spore Length

Culture number measuring (in microns)								
11.70	13.10	13.90	14.60	16.10	16.80	17.50	19.00	20,50
L 24	M 16	M 19	M 12	M 2	M 20	M 26	M 1	M 7
	M 17		M 13	M 3	M 21			M 11
	M 18	L 1	M 14	M 4		Av. 5		
		L 2	M 15	M 5				
	Le 4			M 6				
	Le 5		P 1	M 8				
			P 3	M 9				
	L 4		P 4	M 10				
	L 5		P 5	M 22				
	L 6		P 6	M 23				
	L 7		P 7	M 24				
	L 8		P 9	M 25				
	L 22			M 26				
	L 25		O 1	M 27				
	L 26		O 2	M 28				
			O 3	M 29				
			O 4	M 30				
			O 5					
			Le 1	P 2				
			Le 2	P 8				
			Le 3	P 10				
			L 9	L 3				
			L 10	L 13				
			L 11					
			L 12	Av. 1				
			L 14	Av. 2				
			L 15	Av. 3				
			L 16	Av. 4				
			L 17					
			L 18					
			L 19					
			L 20					
			L 21					
			L 23					
			Av. 6					

TABLE VIII

Shows Effect on Medium on Spore Mean Length (in Microns)

Strain No.	2% Glucose agar	2% Saccharose agar	2% Dextrine agar	Oatmeal agar
M 7	19.25 ± 0,085	16.08 ± 0.047	16.92 ± 0.027	16,51 ± 0.031
M 8	17.28 ± 0.095	16.23 ± 0.050	18.03 ± 0.024	15.50 ± 0.048
M 9	16.70 ± 0.085	18.31 ± 0.063	19.49 ± 0.060	15.32 ± 0.072
M 12	17.37 ± 0.064	16.61 ± 0.071	16.62 ± 0.053	18.05 ± 0.055
M 15	17.05 ± 0.066	15.95 ± 0.043	18.05 ± 0.014	16.72 ± 0.065
O 1	16.03 ± 0.047	15.17 ± 0.030	15.80 ± 0.027	14.25 ± 0.071
O 2	15.17 ± 0.041	16.6 ± 0.022	14.90 ± 0.036	14.43 ± 0.020
P 5	16.08 ± 0.046	13.98 ± 0.046	15.08 ± 0.049	14.24 ± 0.079
P 7	16.35 ± 0.095	14.32 ± 0.021	15.03 ± 0.052	14.27 ± 0.028
L 1	14.55 ± 0.121	16.51 ± 0.057	16.72 ± 0,020	16.07 ± 0.037
L 3	15.25 ± 0.096	14.33 ± 0.039	15.38 ± 0.049	13.66 ± 0.042
L 5	15.63 ± 0.052	16.21 ± 0.034	18.03 ± 0.031	16.89 ± 0.064

TABLE IX

Length Measurements in Microns of Fresh Spores of *C. gloeosporioides* and *G. limetticolum*

Source of Fresh Spores	Maximum	Mean	Minimum
Mango blossom blight	19.04	16.87 ± 0.036	13.19
Mango fruit spots	22.00	16.12 ± 0.049	11.73
Mango fruit spots	23.45	17.50 ± 0.029	13.19
Avocado rot	20.50	19.04 ± 0.032	11.73
Lime thorn spots	16.12	14.66 ± 0.021	11.73
Lime leaf spots	43.98	14.60 ± 0.099	11.73
Lime withered twig	24.92	13.29 ± 0.066	13.19
Lime withered twig	26.39	14.66 ± 0.035	10.26
Lime withered twig	23.45	16.12 ± 0.085	10.26

TABLE X

Maximum, Mean and Minimum Widths in Microns of Cultures of *C. gloeosporioides* and *G. limetticolum*

Culture	Maximum	Mean	Minimum
M 12	5.42	4.40 ± 0.017	3.22
M 17	5.57	4.61 ± 0.081	3.66
M 18	5.72	4.43 ± 0.062	4.10
M 20	5.72	4.62 ± 0.089	4.10
M 22	5.57	4.69 ± 0.027	4.10
M 26	5.42	4.43 ± 0.069	3.66
M 27	5.42	4.37 ± 0.078	3.22
M 29	5.42	4.45 ± 0.088	2.98
P 1	5.42	5.13 ± 0.080	3.66
P 2	5.42	4.54 ± 0.090	3.51
P 4	5.42	4.41 ± 0.066	4.10
P 5	5.57	5.16 ± 0.081	4.40
P 6	5.42	4.69 ± 0.039	3.22
P 7	5.57	4.25 ± 0.045	2.98
P 8	5.57	4.40 ± 0.086	4.10
P 9	5.57	4.48 ± 0.035	3.66
P 10	5.72	5.24 ± 0.086	4.10
O 1	5.57	4.66 ± 0.049	4.10
O 2	5.42	5.18 ± 0.023	3.22
O 4	5.57	4.38 ± 0.041	3.22
Le 1	6.16	4.47 ± 0.087	4.10
Le 3	5.13	4.46 ± 0.075	3.66
Le 4	5.42	4.58 ± 0.032	4.10
Le 5	5.42	4.54 ± 0 035	4.10
L 22	5.42	4.29 ± 0.044	2.98
L 2	5.57	4.46 ± 0.037	3.22
L 23	5.57	4.55 ± 0.086	3.51
L 24	7.33	4.98 ± 0.027	3.66
L 25	6.16	4.92 ± 0.018	3.66

PLATES I–VI

LEGEND FOR PLATE I

FIGURE 1.—Mango leaf showing spots caused by *Colletotrichum gloeosporioides*.

FIGURE 2.—Blight of lime blossoms produced by *Gloeosporium limetticolum*. (A) Lesions on the petals. Young fruits (B) with diseased stigmas shown in black (1, 2); normal young fruit (3).

FIGURE 3.—Withered twigs of the mango caused by inoculations with *C. gloeosporioides*. *a*, Mango cultures; *b*, Avocado cultures; *c*, Pomelo cultures; *d*, Orange cultures.

FIGURE 4.—Setæ of *C. gloeosporioides* on *a*, Oat-meal agar; *b*, Nutrient agar; *c*, Cook's No. 11 agar; *d*, Avocado cultures on Cook's No. 11 agar.

FIGURE 5.—Cross-section of a pustule of *C. gloeosporioides* on lime stigma. Shows conidiophores, conidia and setæ.

FIGURE 6.—Cross-section of pustule of *C. gloeosporioides* on the lime.

FIGURE 7.—Wither-tip of the lime caused by *G limetticolum*.

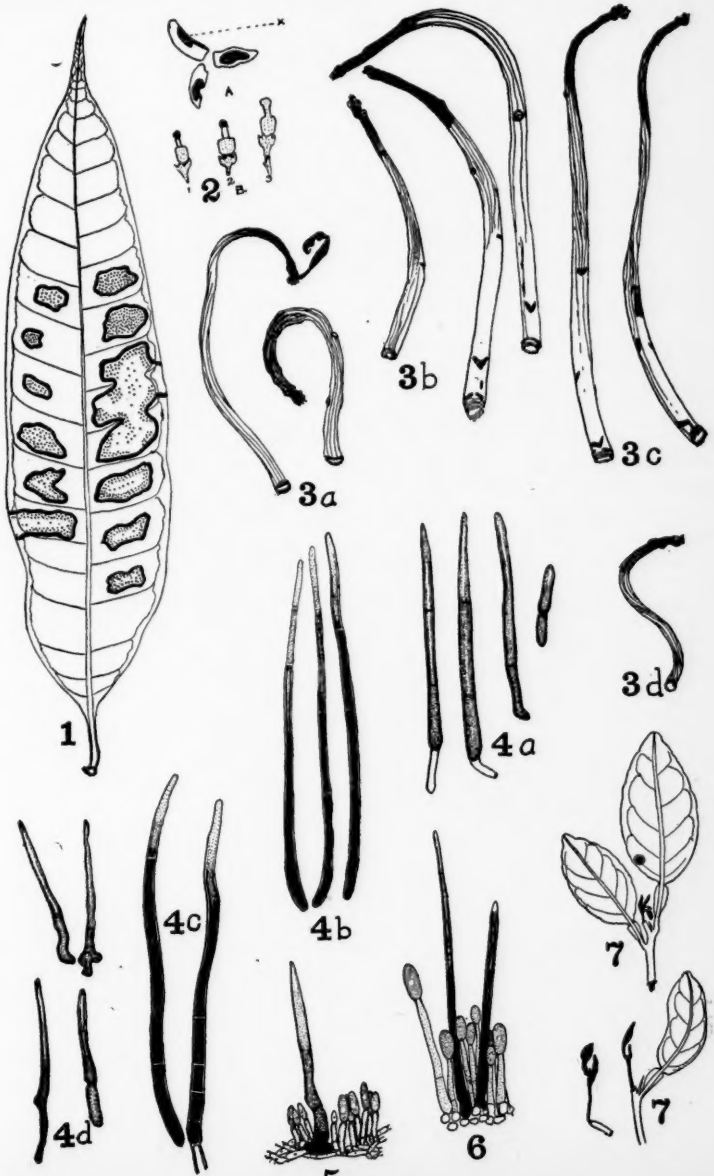

PLATE I

LEGEND FOR PLATE II

FIGURE 8.—Spores of *G. limetticolum* showing blunt ends.

FIGURE 9.—Spores of *C. gloeosporioides* showing blunt ends.

FIGURE 10.—Spores of *G. limetticolum* showing constriction.

FIGURE 11.—Spores of *C. gloeosporioides* showing constriction.

FIGURE 12.—Spores of *G. limetticolum* showing ends more or less pointed.

FIGURE 13.—Spores of *C. gloeosporioides* showing ends more or less pointed.

FIGURE 14.—Shows character of the plasma of spores of *G. limetticolum*.

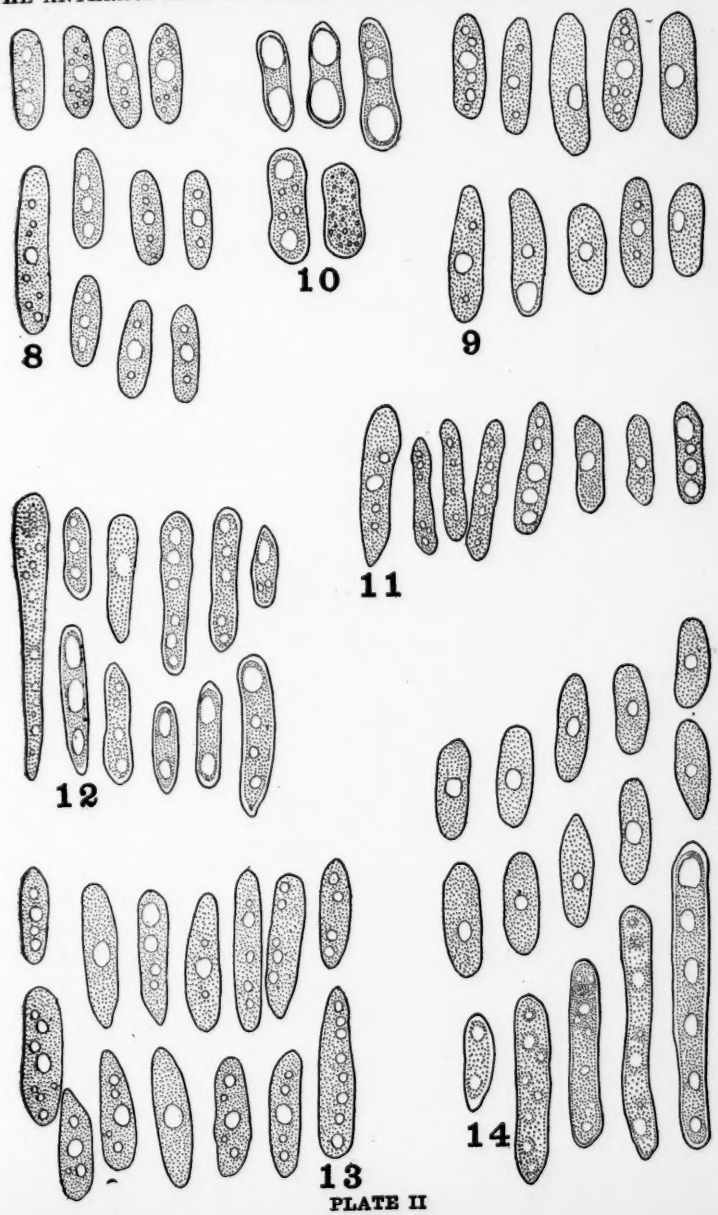

PLATE II

LEGEND FOR PLATE III

FIGURE 15.—Shows character of the plasma of spores of *C. gloeosporioides.*

FIGURE 16.—Spores of *G. limetticolum* showing contraction of the plasma.

FIGURE 17.—Spores of *G. limetticolum* showing different forms and shapes which occur in culture media.

FIGURE 18.—Spores of *C. gloeosporioides* showing various forms and shapes which occur in culture media.

FIGURE 19.—Conidiophores of the avocado culture of *C. gloeosporioides.*

FIGURE 20.—Conidiophore of the mango culture of *C. gloeosporioides.*

FIGURE 21.—Conidiophore of the lime fungus *Gloeosporium limetticolum.*

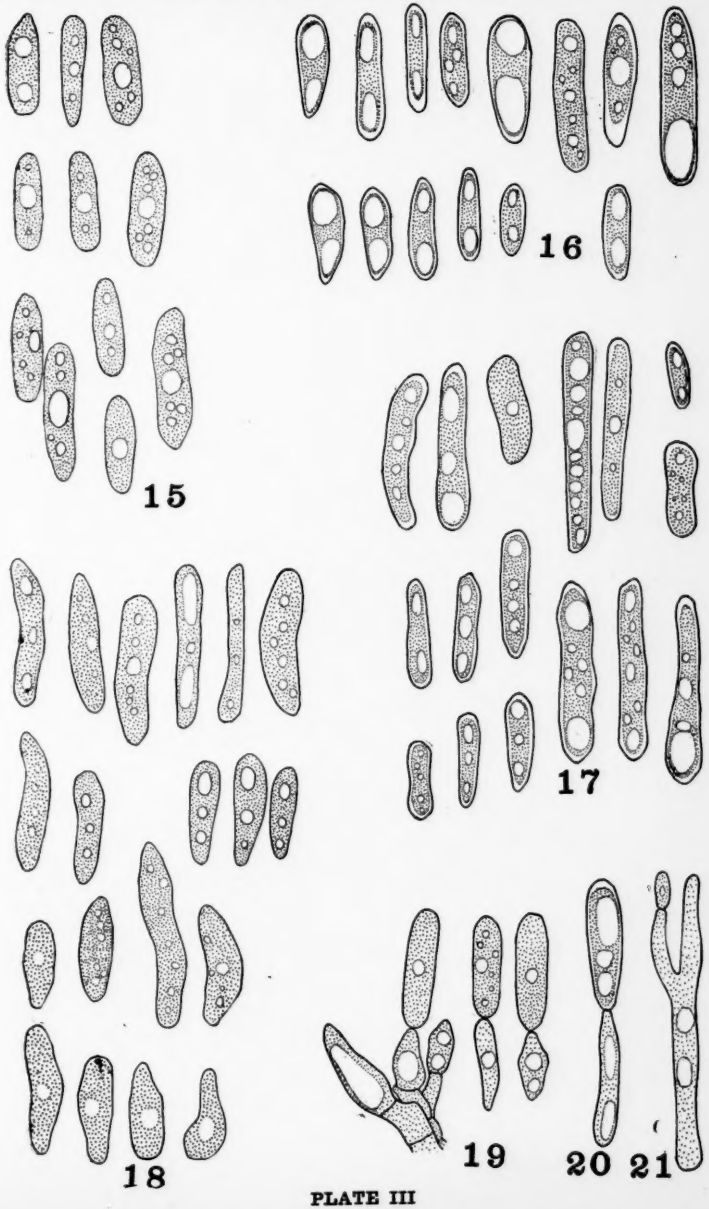

PLATE III

LEGEND FOR PLATE IV

FIGURE 22.—*Colletotrichum gloeosporioides* on +15 nutrient agar. Culture from orange.

FIGURE 23.—*C. gloeosporioides* on —15 nutrient agar. Same culture as in Fig. 22.

FIGURE 24.—*C. gloeosporioides* on +15 agar. Culture from lime.

FIGURE 25.—*C. gloeosporioides* on —15 agar. Same culture as in Fig. 24.

FIGURE 26.—*C. gloeosporioides* on maltose agar. Culture from orange.

FIGURE 27.—*C. gloeosporioides* on maltose agar. Culture from lime.

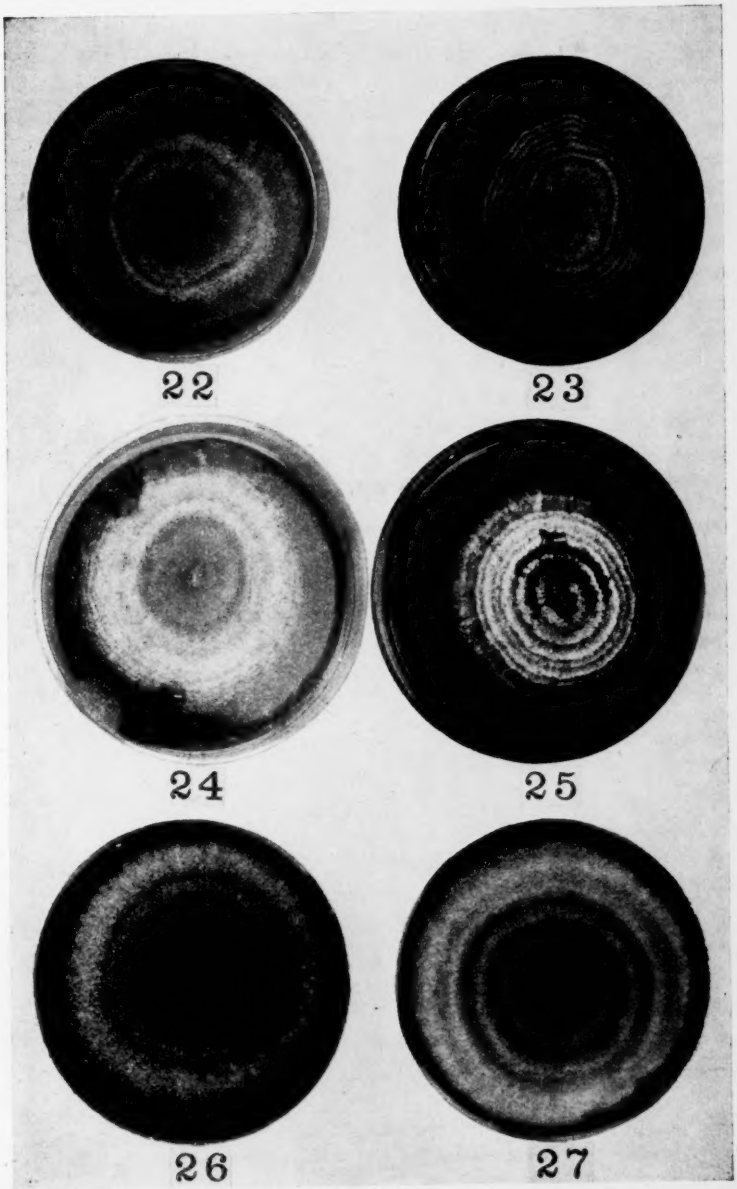

PLATE IV

LEGEND FOR PLATE V

FIGURE 28.—*Gloeosporium limetticolum* on maltose agar.

FIGURE 29.—*G. limetticolum* on maltese agar. Different culture from Fig. 28.

FIGURE 30.—*G. limetticolum* on lactose agar.

FIGURE 31.—*C. gloeosporioides* on lactose agar. Culture from mango.

FIGURE 32.—*C. gloeosporioides* on sucrose agar. Culture from mango.

FIGURE 33.—*C. gloeosporioides* on sucrose agar. Culture from avocado.

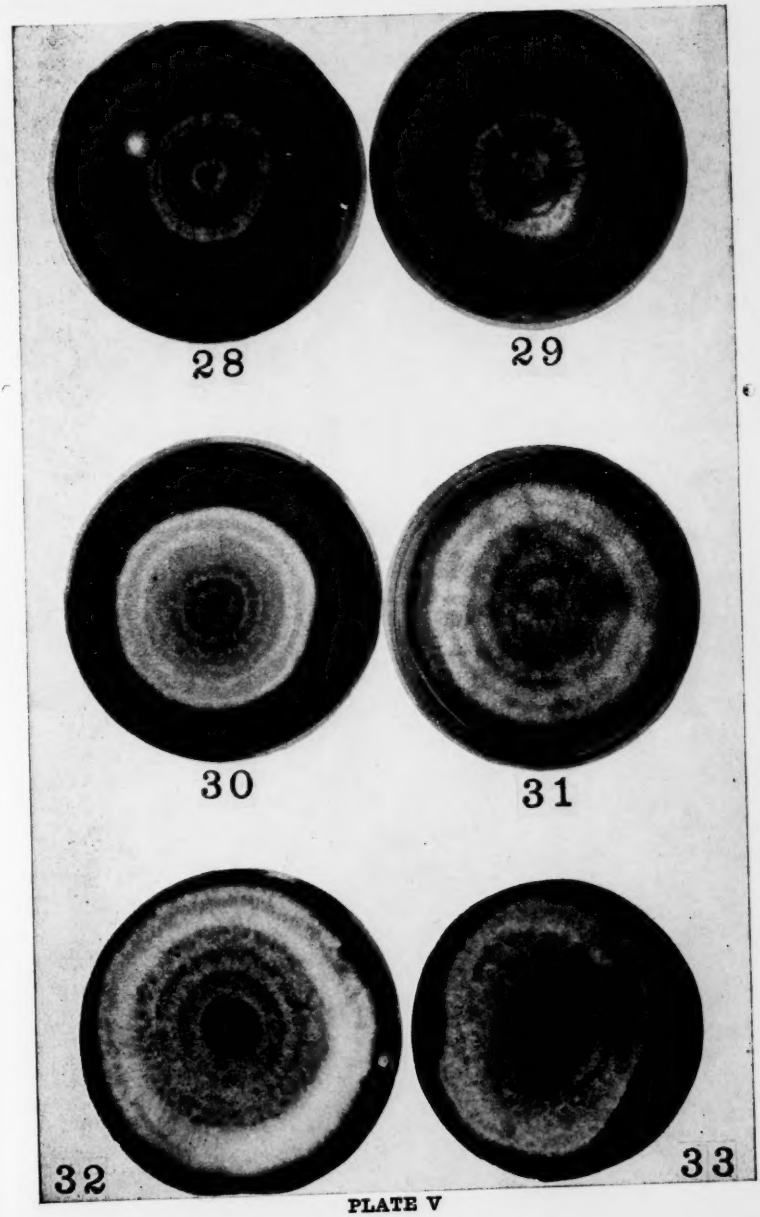

PLATE V

LEGEND FOR PLATE VI

FIGURE 34.—*C. gloeosporioides* on oat-meal agar. Culture from avocado.

FIGURE 35.—*C. gloeosporioides* on glucose agar. Culture from avocado

FIGURE 36.—*C. gloeosporioides* on corn-meal agar. Culture from avocado.

FIGURE 37.—Canker or fruit spot of the mango.

FIGURE 38.—Canker or fruit spot of the lime.

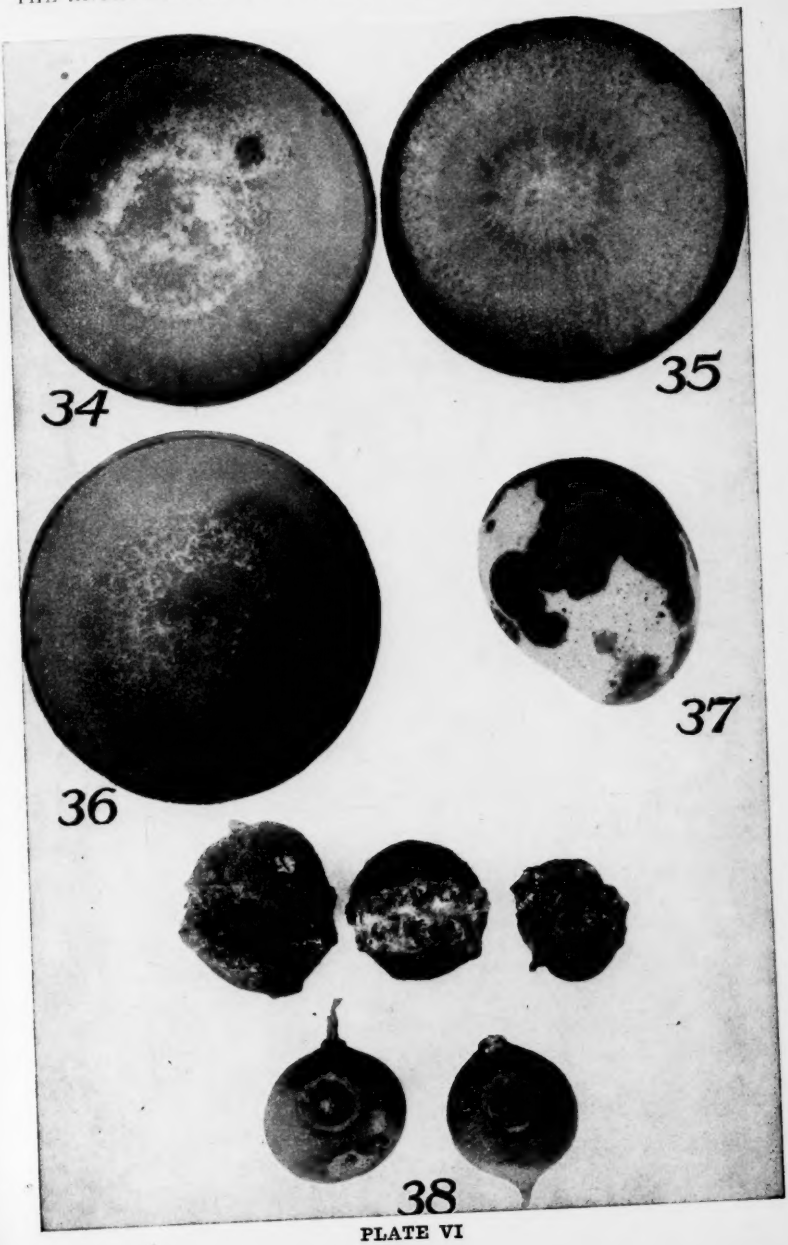

PLATE VI